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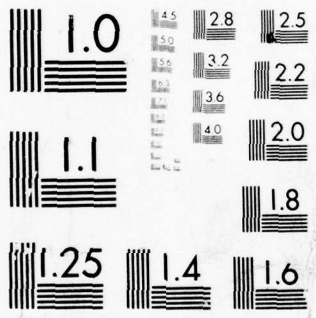
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DYNAMIC MONITORING FOR LINEAR LIST DATA STRUCTURES

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In this report, the contributions that dynamic monitoring can make in the area of software maintenance are discussed. New techniques that enable monitoring of most array-implemented linear list data structures are presented. The main advantage of these assertion techniques is the ability to construct a loop around a group of simple assertions. With this construct, the programmer can explicitly define the record traversal scheme for a linear list data structure implemented with either sequential or linked-list record allocation.

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1. INTRODUCTION

One of the major problems in maintaining large-scale software is the difficulty of understanding the dynamic behavior of the software system. In order to gain a good understanding of the dynamic behavior, it is necessary to have effective dynamic monitoring techniques which are applicable to large-scale software. One approach is to build self-metric software in which the software system has built into itself the mechanisms for measuring its own behavior. However, the large quantity of data collected must be analyzed. The software can also have these analysis mechanisms built into it giving the software system the capability of measuring and evaluating its own behavior. When this evaluation is used to determine whether the software is behaving properly, the software is called self-checking software.

A software system can be characterized as a collection of inter-related assumptions and decisions among modules. Each module makes assumptions about its operating environment. Based on these assumptions the module designer makes a number of decisions about the properties of the module. These decisions completely characterize the external behavior of the module. They become the properties expected of the module by other modules that interact with it. Thus, a module uses a collection of assumptions and makes one or more decisions which are in turn used as assumptions by other modules throughout the system.

During software modification, new errors are frequently introduced into the system in the following way. A modification is made to program module X which changes the definition of a decision D made in that module. Thinking that he has made a complete and successful modification, the programmer begins testing the new version. If everything seems to function correctly, the new version is considered correct and put into production usage. However, the problem arises because some module Y contains code which uses decision D as an assumption. D has been changed and module Y may no longer function properly. If the system is large and the modification relatively small, the testing was probably not very extensive with respect to complete testing. The necessary conditions for failure might not have been generated, or the malfunction might have been so subtle that it went undetected at the time it occurred. In either case, the new version of the software system contains errors due to the software modification.

The maintenance programmer works under a serious handicap. He must work without much knowledge of the execution behavior characteristics of the various control and data variables that comprise the software system. When looking at a particular block of code, it is difficult to determine what assumptions are used and what decisions are made and passed on to other parts of the system. If a decision is to be changed, it is difficult to identify all the other blocks of code where that decision is used as an assumption.

Significant progress is currently being made in research aimed at being able to trace all the possible decision/assumption paths eminating from any given block of code. However, there is a need for a practical tool to help ease the burden on the maintenance programmer. Dynamic monitoring techniques based on the use of assertions can provide that valuable tool. Well formulated assertions will serve as explicit statements of many of the execution behavior characteristics relevant to each block of code in the system. Assertions will also detect assumption violations introduced during incorrect modifications to the software system.

The use of assertions was first introduced by Satterthwaite [1], who used the assertions to check the truth of logical expressions in a program. If an evaluation was false, the program was forced to abnormally terminate and a post-mortem analysis was initiated. Stucki [3] has presented a more sophisticated dynamic monitoring scheme which has been added to PET (Program Evaluation and Tester) [2]. Along with the assertions on logical expressions used by Satterthwaite, Stucki included assertions on legal and illegal values and ranges of variables. These techniques were still designed primarily for use on simple variables. Stucki [4] later described extensions to this language that makes it usable with simple array structures. But, even these extensions have several serious shortcomings with respect to monitoring array implementations of linear list data structures. The most serious problem is that the programmer can only specify the range for the index variable, but not the exact sequence of values the index should take. Even this range specification cannot be used to its full potential since it is a static definition and does not represent the true dynamic behavior of the data structure. Finally, if several assertions are to be made on the same array, the index specifications must laboriously be included with each assertion statement. Recently, Chow [5] has presented a method for using past as well as present program status in the assertions of logical expressions. While the ideas presented are interesting, they are not dealing with the monitoring of array structures.

In this report we will discuss dynamic monitoring with assertions and how it can be of benefit in the software maintenance process. We will also discuss the use of an assertion language compared to other possible alternatives. We will then present an advancement to the current assertion specification techniques that enables dynamic monitoring of most array-implemented linear list data structures. The main feature of our new techniques is the ability to construct a loop around a group of simple assertions. With this loop construct, the programmer can explicitly define the record traversal scheme for a linear list data structure implemented with either sequential or linked-list record allocation. Within the assertion loop, Stucki's simple logical expression and value assertions can then be used on the individual array items defined by the loop index.

We will give a number of examples to illustrate how these techniques may be used in typical JOVIAL tables and arrays. The example will include various linear list data structures, and both sequential and linked-list allocation schemes. We will also discuss the implementation of an assertion language preprocessor for a JOVIAL system. As a demonstration, we have modified JAVS [6-8] so that it recognizes and translates our proposed assertion constructs. We will also discuss how these techniques are applicable to other high level languages.

2. ASSERTION CONCEPTS

2.1 The Assumption/Decision Model

An ideal situation would be to have assertions written to verify all of the assumptions made by each of the modules in this system. This would provide complete documentation of expected run-time behavior as well as a means for each module to check if the outside environment is really as it is claimed to be. Some assumptions, such as legal values and ranges of input variables, readily lend themselves to specification as assertions. However, more complex assumptions concerning large data structures or relationships between various variables may be too complicated to be specified and thoroughly verified in a run-time situation.

In the same manner, assertions can be included for decisions made within each module. This will provide documentation as well as run-time verification of correct implementation of each decision. If a decision is incorrectly implemented, it may be detected and identified at virtually the location of the error. This will save lots of debugging time. As with the assumptions, not all of the decisions can be easily formulated into simple assertions.

More research will be required to determine what percentage of all the assumptions and decisions can be easily specified as dynamic assertions.

2.2 A Software System Life Cycle

Assertions should be a part of the entire life cycle of a large scale software system. They should be considered in the initial design and coding phases and will be of useful service as long as the system is being maintained.

During the initial design phase of the system, each module designer must identify the assumptions used and the decisions made by his module. These assumptions and decisions should then be included as assertions in the initial version of the coded module. From that point on, the assertions will serve as important documentation of the expected execution-time behavior characteristics of that module. The assertions included in each module will be useful when testing the individual modules and then the system as a whole. They will help detect and identify some errors earlier than otherwise might be the case. They may also detect errors that would otherwise go unnoticed. Thus, initial testing can be quicker and more thorough.

When the system has been thoroughly tested and is ready for use in the field, it would be recompiled without the assertions. The assertions would remain as comments but they would not be converted into executable code. Thus, no space or time overhead is added to the production system.

When it is necessary to perform a modification on the system, the assertions can again play a very helpful role. Before attempting any changes, the maintenance programmer must thoroughly examine the relevant modules and become familiar with both their static and dynamic characteristics. He must be aware of what assumptions are used in the system. Well formulated assertions provide the needed documentation.

But errors can still be made. To minimize the amount of damage done, it is important that these errors be detected as early as possible. By again compiling the assertions in the related parts of the system, the programmer has a powerful tool for detecting any abnormal system behavior, something that is otherwise very difficult to do. Errors that are introduced into the system during program modification usually occur through the decision/assumption relationship. A decision in one module may get changed making the assumption used consistent with the new decision from the first module, it may not function correctly. Thus, errors are introduced when the second module is left unchanged using an old assumption. The assumption assertion in the problem's second module would assist by noticing the assumption violation and identifying it to the maintenance programmer.

2.3 An Assertion Language

Thus far, our discussion of assertions has not been concerned with how they might be specified. For years, many good programmers have included input parameter checks in their routines reflecting a "I don't trust anyone" philosophy. These first assertions were coded along with the regular program and frequently remained in the finished product. This has an adverse effect on the space and time efficiency of the completed software system. We need assertions that can always remain in the source code, but yet don't always have to be compiled or executed.

The simplest method to achieve this desired control is to continue writing the assertions in the high-level language of the system, but include a special flag with each statement to indicate that it is part of an assertion. Then, prior to compilation the specially flagged statements could be converted to comments or left as executable code by a simple preprocessor.

A more sophisticated approach involves the use of a specialized assertion language. There are several reasons we feel that such an approach is desirable. First, an assertion language provides a simple syntax that is tailored to the checks that must be expressed. The assertions can be written in a much more concise manner than would otherwise be possible. For instance, the value assertion as defined by Stucki [2] is much simpler than the equivalent statements in any high-level language. The programmer is also spared from worrying with the output that must be generated if an assertion violation occurs. He knows that for each assertion, the preprocessor will generate statements to output a standard-form violation message. Also, this concise, tailored format means that each assertion statement is self-documenting; it is easily readable and readily stands apart from the remainder of the code.

Second, an assertion language overcomes a major problem associated with assertions written in the language of the software system. When assertions are written in the same language as the total software system, it is difficult to maintain the desired separation between the assertions and the remainder of the code. If the statements that make up an assertion are not flagged as assertions promptly when they are written, they will likely never be so flagged. This is because without an indepth study of the code, it is usually quite difficult to determine if a statement is part of an assertion or the real program. More than likely, the final program will have both flagged and unflagged assertion statements. Then, when the assertions are to be disabled, these unflagged assertions may cause either compilation errors or additional time-and-space overhead, or both. An assertion language avoids this problem; the assertions always remain distinctly separate from the rest of the code.

Another benefit is the ease with which the programmer can control the enabling of the assertions. In the simple case, a preprocessor can either convert all the assertions to the appropriate high-level code or leave them as comments in that language. In a more powerful approach, the assertion language could include a complex hierarchy of control giving the programmer both compilation and execution-time control over the enabling of individual assertions [4].

All these reasons for using an assertion language basically come down to convenience and reliability. They are the same general reasons that the software is being written in a high-level language instead of in an assembly language. The programmer's time is valuable and we can expect a more reliable product.

However, there are some drawbacks to the use of an assertion language. First, a simple preprocessor must be written that will translate the assertion statements into the desired high level code. Since an assertion language can be kept simple, this does not appear to be a serious problem. Secondly, the assertion language is less flexible than the high level language that would otherwise be used. However, using Stucki's simple assertions and the advancement we propose in the remainder of this report, we feel that most desired assertions can be easily stated.

Overall, we feel that a powerful assertion language provides significant benefits in the specification of dynamic assertions.

3. ARRAY DATA STRUCTURES

The array is a commonly used data structure, one that is explicitly defined in almost all high-level languages. Yet current dynamic monitoring techniques are not usable with any but the simplest array structures.

An array is defined as a collection of homogeneous items that may all be referenced by the same name. Sometimes these items are merely elementary items of the language. Yet frequently they are themselves collections of other items that are non-homogeneous and/or logically related to each other. These latter collections are called records though each language seems to have its own unique terminology. Arrays of records are explicitly provided for in JOVIAL [9], PASCAL [10], PL/I [11], ALGOL 68 [12] and COBOL [13] although in JOVIAL these structures, called tables, are only one-dimensional.

FORTRAN [14] is a prominent high-level language that has no explicit record structure. There are two common techniques used to overcome this deficiency. The first method is to create a separate array for each individual item of the record. The other way is to implement m-dimensional records of an n-dimensional space using an n + m dimensional array. Either way, there is still the logical concept of an array of records.

In general, we can consider every array to be an array of records. These records may be elementary items, explicitly defined record structures or implicitly defined FORTRAN records. Thus, when specifying dynamic assertions for arrays, we want to treat the arrays as record-oriented data structures.

4. ASSERTION TECHNIQUES FOR LINEAR-LIST DATA STRUCTURES

4.1 Record-Oriented Monitoring

As noted above, most of the data structures explicitly defined in current programming languages are record-oriented organizations. We feel that dynamic assertion techniques for these structures ought to represent this record philosophy.

There are two things that the programmer must define in order to specify dynamic assertions for a record-oriented structure.

1) The group of simple assertions that is to be applied to each record in the structure.
2) A systematic means of accessing each record in the structure.

The simple assertions should be those already defined in the existing language for use with simple variables. A language construct must be defined that will have the assertions together as a group that will be applied to each record. The systematic access of records for the general class of all data structures is not a simple task. Therefore, for the rest of the report, we will limit our discussion to linear lists, a class of data structures in common use in today's programming practices.

4.2 Linear Lists

A linear list is a set of n ≥ Ø nodes x[1], x[2],...,x[n] whose structural properties essentially involve only the linear (one-dimensional) relative positions of the nodes [12]. Three special linear lists: stacks, queues and deques; allow deletions, additions and accesses to values only at the first or last node of the structure. Typically, these are implemented using a sequential storage allocation scheme. The more general class of linear lists allows additions, deletions and accesses to any node in the list. Typically, some sort of linked record allocation is used for these more general linear-list structures. Methods for specifying systematic traversal schemes for both types of allocation will be presented in the following section.

4.3 Node-Traversal Schemes

To specify the traversal of any data structure, three characteristics of the traversal must be defined:

1) the first node to look at
2) the method for determining the next node
3) the condition that signals the end of the traversal.

As is done within the program itself, an index will be used for specifying the desired elements of the data structure. Our definitions for the first and next nodes will be values for the controlling index. The terminating condition will be any general Boolean expression.

The traversal scheme specification will take the form of a standard high-level program loop. The loop conditions will define the sequence of records to be monitored and within the loop bounds will be grouped the assertions for each record.

4.3.1 Sequential Allocation

If the records are stored in a sequential manner in the data structure, then the range for the index variable is sufficient to define the traversal. A simple loop definition using the range specification takes the following format:

```
LOOP(⟨variable name⟩) (⟨range⟩)
      .
      .
      .
END LOOP
```

For example, consider a JOVIAL table with N records stored in sequential order starting in record Ø. The following would define the assertions loop.

```
LOOP (I) (Ø...N-1)
      .
      .
      .
END LOOP
```

A JOVIAL assertion preprocessor would generate the following JOVIAL code and insert it into the original source code.

```
FOR I = Ø, 1, N-1  $
BEGIN
  .
  .
  .
END
```

This type of assertion can also be applied equally well to software systems written in other languages. For instance, the assertions on a FORTRAN array of N elements would look very similar to those written above for the JOVIAL example.

```
LOOP (I) (1...N)
      .
      .
      .
END LOOP
```

The translation to FORTRAN would then be as follows: where STMT denotes a unique FORTRAN statement number.

```
                DO STMT I = 1, N
                    .
                    .
                    .
          STMT  CONTINUE
```

4.3.2 Linked Allocation

A more complicated situation exists when the records are stored in a linked manner scattered throughout the physical data structure. The initial value for the control index is generally taken from a variable maintained by the main program as a pointer to the first record. The next value for the index usually is taken from a link field within the current record. And the terminating condition is stated as a Boolean expression that when evaluated true, denotes that the end of the chain has been reached. Frequently this condition is that the link field of the current record, and subsequently the next value of the index variable, is an implementation-dependent null pointer. The syntax for this loop definition is:

```
CHAIN (⟨index variable⟩) INIT (⟨arith. expr.⟩)
NEXT (⟨arith. expr.⟩) END (⟨boolean expr.⟩)
                      .
                      .
                      .
END CHAIN
```

For example, consider a JOVIAL table that contains a linked list. Simple item PTR contains the index for the first record in the chain. The table contains item LINK which provides the link between records and is -1 in the last record of the chain. To loop through this linked list, the following directives would be used.

```
CHAIN (IX) INIT (PTR) NEXT (LINK($IX$)) END (IX EQ -1)
                         .
                         .
                         .
END CHAIN
```

The assertion preprocessor would then generate and insert the following JOVIAL source statements.

```
          IX = PTR $
Label.
              .
              .
              .
          IX = LINK($IX$) $
          IF NOT (IX EQ -1) $
          GOTO Label $
```

Label is used to denote a preprocessor-generated label that is unique to this loop expansion. Again this type of assertion is also applicable to software systems written in other languages. For example, consider how the above example might look in a FORTRAN system. The linked list is stored in a 2-dimensional array, LLIST, with each row being a record of the logical structure. The first element of each row contains the link to the next logical record. Now our assertions would look as follows.

```
CHAIN (IX) INIT (PTR) NEXT (LLIST(IX,1)) END (IX .EQ. Ø)
     .
     .
     .
END CHAIN
```

The preprocessor might convert this to FORTRAN as indicated below, where again STMT is used to denote a uniquely generated statement number.

```
      IX = PTR
STMT  CONTINUE
        .
        .
        .
      IX = LLIST(IX,1)
      IF (.NOT. (IX .EQ. Ø)) GO TO STMT
```

4.4 Empty Data Structures

One important consideration that has not yet been accounted for is the possibility that the data structures might be empty. If that is the case, then the loop and the assertions defined within the loop should not be executed. To handle this situation, an optional EMPTY (⟨boolean expr.⟩) clause may be appended to either of the previously-defined loop-specification statements as follows:

```
LOOP (⟨variable⟩) (⟨range⟩) [EMPTY (⟨boolean expr.⟩)]
                       or
CHAIN (⟨variable⟩) INIT (...) NEXT (...) END (...)
            [EMPTY (⟨boolean expr.⟩)]
```

A true evaluation of the Boolean expression indicates that the data structure is empty and the assertions should be skipped. The JOVIAL preprocessor would group the whole assertion loop as a compound statement and precede it with an appropriate IF statement as shown below:

```
IF NOT (⟨boolean expression⟩) $
BEGIN
   Loop as defined previously
END
```

In the two examples discussed in Sections 4.3.1 and 4.3.2, the EMPTY Boolean expressions might be "N EQ Ø" and "PTR EQ -1".

4.5 Examples

In this section, we will show some examples detailing how the assertion loops could be used for typical linear-list structures and allocation schemes. At this point we are only concerned with the record-traversal scheme and thus will not try to show any specific assertions.

4.5.1 Stack - sequential allocation

Consider a JOVIAL table, STACK, that contains a stack of records. The stack is filled from the bottom (index = Ø) up and NENT(STACK) contains the number of entries in the stack. The loop and assertions, including an empty stack check, could be written as follows:

```
LOOP (I) (Ø...NENT(STACK)-1) EMPTY (NENT(STACK) EQ Ø)
   Assertions
END LOOP
```

The preprocessor would generate the following JOVIAL code:

```
IF NOT (NENT(STACK) EQ Ø) $
BEGIN
  FOR I = Ø, 1, NENT(STACK)-1 $
  BEGIN
     Assertions
  END
END
```

4.5.2. Queue - sequential allocation

To implement a first-come-first-serve queue, a large JOVIAL table, QUEUE, might be used. Records are added to one end of the sequential list and removed from the other. The queue moves progressively around the fixed length table. HEAD is used here to point to the oldest record in the queue, the one that will be serviced next. TAIL points to the next record to be filled at the end of the queue. When the queue is empty, HEAD = TAIL. QUELEN is the length of the table.

Because of its cyclic nature, the queue is always in one of three possible states as shown in Figure 1. Because of the difference of the relative values of HEAD and TAIL, these three cases cannot all be monitored using the same assertion-loop definition. Instead, we will use a JOVIAL IF-EITHER statement to separate case 3 from cases 1 and 2 as follows:

```
IFEITH HEAD LQ TAIL  $
   BEGIN "CASES 1 AND 2"
      LOOP (I) (HEAD...TAIL-1) EMPTY (HEAD EQ TAIL)
         Assertions
      END LOOP
   END "CASES 1 AND 2"
ORIF HEAD GT TAIL  $
   BEGIN "CASE 3"
```

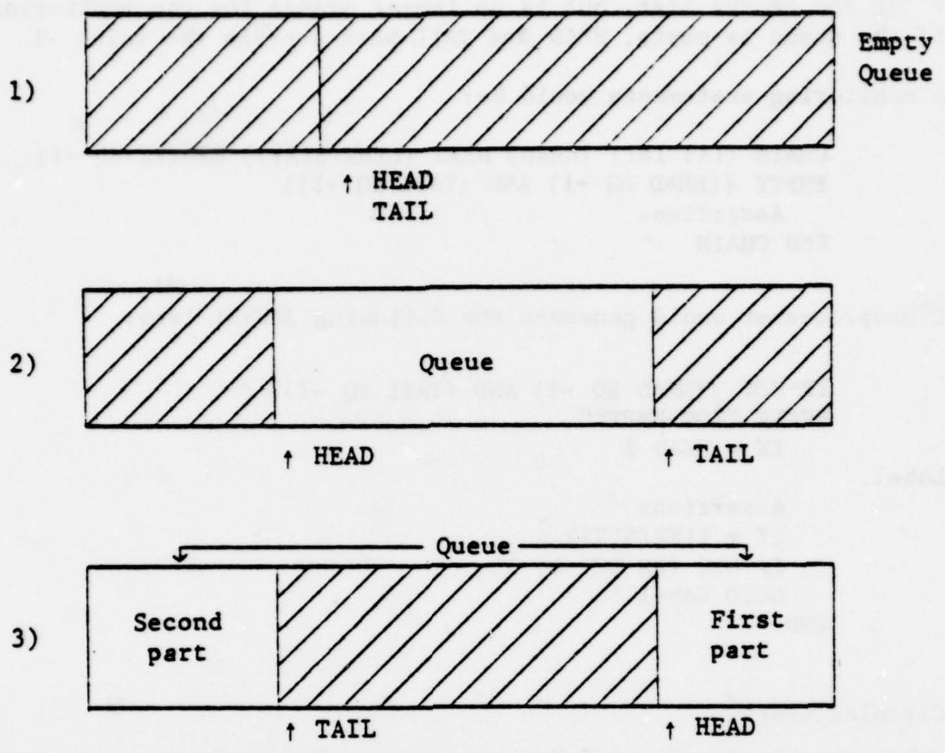

Fig. 1. Queue Implemented in Sequential Allocation
(The shaded areas represent empty records).

```
            LOOP (I) (HEAD...QUELEN -1)
               Assertions
            END LOOP
            LOOP (I) (Ø...TAIL -1)
               Assertions
            END LOOP
         END "CASE 3"
      END "IF EITHER"
```

For each of the assertion-loop definitions, code similar to that for the stack in Section 4.5.1 would be generated by the JOVIAL preprocessor.

4.5.3 Queue - linked list allocation

Consider again the queue in the previous section, only this time being implemented as a linked-list of records. Table item LINK is added and provides the proper linkage between the records. In the last record, the LINK field contains the value -1. HEAD still points at the oldest record, what is now the first record in the list. TAIL points to the most recent record added at the end of the list, but is no longer needed for the monitoring process. If the queue is empty, HEAD and TAIL both contain the value -1.

The monitoring statements would be:

```
CHAIN (IX) INIT (HEAD) NEXT (LINK($IX$)) END(IX EQ -1)
EMPTY ((HEAD EQ -1) AND (TAIL EQ -1))
   Assertions
END CHAIN
```

A JOVIAL preprocessor would generate the following JOVIAL loop:

```
                IF NOT ((HEAD EQ -1) AND (TAIL EQ -1)) $
                BEGIN "NON-EMPTY"
                   IX = HEAD $
        Label.
                   Assertions
                   IX = LINK($IX$) $
                   IF NOT (IX EQ -1) $
                   GOTO Label $
                END
```

4.5.4 Circular Lists

If the queue in Section 4.5.3. was to be implemented now as a circular list, the LINK value for the last record would have to point back to the first record in the list. This would cause a change to the terminating condition in the loop definition as shown below:

```
CHAIN (IX) INIT (HEAD) NEXT (LINK($IX$)) END (IX EQ HEAD)
EMPTY (HEAD EQ -1)
```

It is the circular list data structure that dictates the use of a DO-UNTIL loop in the JOVIAL expansion of the chain traversal definition. If a DO-WHILE loop was used, the terminating condition would be met immediately after the initial index value assignment. In this example, we can see that the initial assignment HEAD→IX would lead to a true evaluation of IX EQ HEAD and thus an exit from the DO-WHILE loop.

4.5.5. Doubly-Linked List

To traverse the records of a doubly-linked list, either one of the chains may be followed. Thus the doubly-linked list structure simplifies into either a linked-list or a circular list as far as the dynamic monitoring of the record values is concerned.

A totally complete set of assertions on a doubly-linked list should also verify that the two chains are consistent with each other. This would involve increased complexity in the loop specification language as well as in the source code generated. At the present time however, the need does not seem to justify the added overhead and complexity that would be required.

4.5.6. Sequential Variable-Length Records

Frequently variable-length records are stored sequentially in a linear array, usually with the first word of each record containing the length of the record as shown in Figure 2. Typically the array acts as a buffer

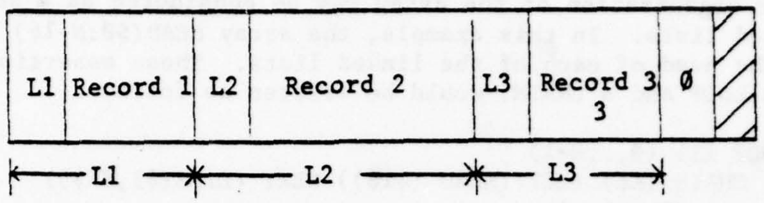

Fig. 2. Array Used as Buffer for Variable-Length Records
(The shaded areas represent empty space.)

for these records between main memory and some sort of secondary storage media.

Our chain-traversal definition is flexible enough to be of easy use with this sort of record organization. In the following example, BUFFER is a linear array. As indicated above, the first word of each record contains the length of that record. Following the last record is a Ø to indicate the end of the list. The loop definition would be written as follows.

```
CHAIN (IX) INIT (Ø) NEXT (IX + BUFFER($IX$)) END (BUFFER($IX$) EQ Ø)
EMPTY (BUFFER($Ø$) EQ Ø)
   Assertions
END CHAIN
```

4.6 Multi-dimensional Linear Structures

Until now we have only demonstrated our assertion approach with 1-dimensional linear lists. However, our techniques are also applicable to the general class of multi-dimensional linear structures. This is accomplished by the use of nested loops, one for each index of the array. Then inside the inner-most loop, the desired assertions can be written for the individual records.

The following examples illustrate the use of nested loops for multi-dimensional arrays. In each example, we will write assertions for an N by M array of records. This array can be viewed as a linear list of N linear lists of M records. Thus, what we must do is to specify the looping constructs for each of the two lists.

The simplest and most common view of our N x M array would consider both lists to be of a sequential nature. We would write the loops for such an organization as follows:

```
LOOP (I) (Ø...N-1)
   LOOP (K) (Ø...M-1)
      Assertions
   END LOOP
END LOOP
```

Another organization of the array may be considered as a sequential list of linked lists. In this example, the array HEAD($Ø:N-1$) contains the pointer to the head of each of the linked lists. These assertion loops, now using both a LOOP and a CHAIN, would be written as follows:

```
LOOP (I) (Ø...N-1)
   CHAIN (KK) INIT (HEAD ($I$)) NEXT (LINK($I,KK$))
   END (KK EQ -1)
      Assertions
   END CHAIN
END LOOP
```

We may also view the array as a linked list of linked lists. The array LISTLINK ($Ø:N-1$) provides the linkages in the list of lists while HEAD ($Ø:N-1$) again contains the head of list pointers for the lists of records. TOP points to the first list of records.

```
CHAIN (II) INIT (TOP) NEXT (LISTLINK($II$)) END (II EQ -1)
   CHAIN (KK) INIT (HEAD($II$)) NEXT (LINK($II,KK$))
   END (KK EQ -1)
      Assertions
   END CHAIN
END CHAIN
```

As demonstrated in these examples, our assertion techniques are applicable to any combination of allocation schemes that might be used in an array structure. They are simple and powerful enough to make assertion specification for multi-dimensional linear structures a simple task.

5. OPTIONAL INTEGRITY CHECKS

Thus far, we have discussed only integrity checks on the data values contained in the various linear data structures. However, with a linked-list structure, it is also important that we are able to check the integrity of certain aspects of its logical structure. Toward this end, we now define the optional BOUNDS and COUNT clauses to be appended to the chain-traversal loop definition as follows:

```
CHAIN (⟨variable⟩) INIT (...) NEXT (...) END (...)
[EMPTY (...)] [BOUNDS (⟨range⟩)] [COUNT (⟨range⟩)]
```

5.1 Bounds

With this clause, the programmer can make an assertion about the legal values that the index variable may take. If the index is out of range, it usually indicates a serious error in the logical data structure. For this reason, after a BOUNDS assertion violation, the assertion loop should be immediately exited. This feature should provide detection of erroneous link field values and data structures that have simply overgrown their assigned memory space.

5.2 Count

This clause specifies an assertion about the legal number of records in the linked list. For instance, if the program maintains its own record count, this clause could monitor the correctness of that count. Another easy use might be to verify that the data structure is indeed empty or non-empty at a particular time. As with the BOUNDS clause, an error message is printed when an assertion violation is detected.

6. SIMPLE ASSERTIONS

In this section we will examine the actual assertions needed for simple and record-oriented items. Stucki [4] has defined one general and five specialized local assertion formats. Three of these seem important within the framework of the current discussion.

1) ASSERT (⟨boolean expression⟩)
2) ASSERT VALUE (⟨variable name⟩) (⟨list of legal values and/or ranges⟩)
3) ASSERT VALUE (⟨variable name⟩) NOT (⟨list of illegal values and/or ranges⟩)

The last two assertions could obviously be written using one or more of the general Boolean expression assertions. However, for clarity and ease of use, we feel that the value-type assertions should also be explicitly defined in the assertion language.

A brief example should adequately illustrate these assertions. Let us again consider the stack from Section 4.5.1, but this time we are interested in the actual assertions that we skipped over previously.

As defined before, I is the index variable, and we will use it to identify the record being examined. If A, B, C, D are items defined in the table, we could see the following assertions on these items.

```
ASSERT (A($I$) * B($I$) GT Ø)
ASSERT VALUE (C($I$)) (1, 5, 10,...15)
ASSERT VALUE (D($I$)) NOT (2, 4)
```

It should be noted here that currently JAVS [7] provides only the general assertion on a Boolean expression.

7. ASSERTION LANGUAGE PREPROCESSOR

In this section we will examine some of the important issues in the implementation of a preprocessor for our new assertion constructs in a JOVIAL system. Some of these implementation issues can effect the way the user may interface with the system. Our purpose here is to present the various alternatives that are available. We will also look at our implementation in JAVS of the preprocessor for an assertion language with these new constructs.

7.1 Index Variables

Both of our new looping constructs define the values for an index variable that is used to identify the desired array elements. Some of the more difficult implementation issues revolve around these indices, and particularly, the way they must be specified in JOVIAL. One of our main objectives must be to supply the user with the simplest possible tool. Yet, this objective will certainly have to be balanced against the realities of the preprocessor implementation.

7.1.1 Variable Types

One issue that ispeculiar to JOVIAL systems and was covered over previously is the matter of index variable types. As the JOVIAL expansions for the LOOP and CHAIN constructs were previously defined, each requires the use of a different type of variable for the index. Since the LOOP command translates into a FOR statement, a one letter FOR variable must be used. On the other hand, the CHAIN command requires the use of a two to six character variable. The programmer must either remember which command requires which type of variable or be aware of the code to which the commands are translated. Neither alternative is very attractive.

An alternate translation for the LOOP construct may provide the best solution. Instead of using a FOR loop, the loop controls could be written explicitly with other JOVIAL structures. The translation for a LOOP command into JOVIAL would then be as follows:

```
          LOOP (IX) (Ø...N-1)
          .
          .
          .
          END LOOP

    translates to

          IX = Ø $
       LABEL.
          .
          .
          .
          IX = IX + 1 $
          IF NOT (IX GR N-1)$
          GOTO LABEL $
```

The normal two- to six-character variable name could then be used for the index variable in both loop constructs.

7.1.2 Interference

It is important that the assertion statements not interfere with the normal execution of the software system. The assertions must have access to all of the main program's variables, yet they must not be allowed to alter the values of those variables. The loop index variables are the only potential problem variables since they are the only ones to which new values are assigned. Ideally the preprocessor should protect the main program from interference by these index variables. Otherwise,the programmer will have to be responsible for avoiding harmful side effects from his assertions.

If the target language for the preprocessor is a block-structured language, such as ALGOL 60 [16], ALGOL 68 [12], PASCAL [10] or PL/I [11], the preprocessor can easily protect the main program from interference by the assertions. This is possible because of the way these languages define the scope of the variables. Any variable x is considered to be local to the block in which it is defined. Variable x can then be accessed as a global variable in blocks nested within the defining block unless the nested block defines its own variable x. In that case, the original x is unreachable yet left unharmed until the lower block is exited. The preprocessor needs only to translate each block of assertions into a block structure of the target language. Within this block the index variable could be declared and used as a local variable. Thus,the assertions have access to all the variables from higher level blocks, and yet the index variable does not interfere with any of the other variables already in use.

However, JOVIAL does not provide such facilities. The scope of a variable is either the entire program or routine in which it is defined. Thus, to avoid interference, the index variable must be unique relative to all the other currently live variables. One solution is for the preprocessor to "guarantee" this uniqueness. It could concatenate a short string onto the variable name to create a new unique name. For example, the string might be XXXX. Then, if the programmer used II for the index variable name, the preprocessor would generate the variable name IIXXXX. This assumes that the programmer knows to avoid using variable names ending with the string "XXXX". This solution may increase a lot of complexity in the preprocessor. A reasonable alternative seems to be to require the programmer to choose a unique index name for his assertions. A better approach may be to always use a particular distinctive name, such as ASSTIX, that would never be used elsewhere in the program.

7.1.3 Declarations

In most programming languages, the programmer must declare all of the variables he intends to use. Since the assertion loop indices are not part of the main program, we feel that the programmer should not need to include declarations for them. This means that the preprocessor must insert the necessary declarations.

In the block structured language approach described in the previous section, the declaration responsibility naturally falls on the preprocessor. Declarations are generated and inserted at the beginning of each assertion block.

For a JOVIAL implementation, the situation is not so well defined. If the preprocessor is creating its own names, then it must also insert the variable declarations. However, if the programmer uses the same index variable name twice and the preprocessor includes two declarations, the compiler will issue a warning message. Certainly this does not represent an ideal solution to the problem. On the other hand, if the programmer is responsible for using unique index variable names, it would seem natural for him to also include the declarations.

7.1.4 JOVIAL conclusions

We feel that both loop constructs should use the same type of index variable as discussed in Section 7.1.1. Regarding variable interference and declarations, a realistic approach is to leave the index variable choice and declaration responsibilities with the programmer. These decisions provide an adequete interface with the programmer while holding down the complexity of the preprocessor.

7.2 Integrity checks

When the COUNT and BOUNDS options were previously introduced, no translations into JOVIAL code were given. The intent of the two clauses was evident without introducing the details of implementation. Here we will discuss those details.

The code for these options must be designed so that it can be easily inserted into the code already specified for a CHAIN loop. This will help keep the option translations a simple process.

7.2.1 COUNT

For the count check we will introduce a specific variable, ASTCNT, that will hold the count of records processed in any particular loop. ASTCNT can be automatically declared at either the beginning of the program or the time of the first count check. The later declaration requires the use of a separate flag to indicate whether or not ASTCNT has already been declared.

For a particular COUNT check, the preprocessor must generate code to initialize, increment and validate ASTCNT. Code must be inserted before, in the middle of, and after the basic assertion loop. For example,

```
CHAIN (IX) INIT (PTR) NEXT (LINK($IX$)) END (IX EQ -1)
COUNT (LOW...HIGH)
:
END CHAIN
```

would be translated to

```
     ASTCNT = Ø $
     IX = PTR $
LABEL.
     ASTCNT = ASTCNT + 1 $
     :
            IX = LINK($IX$) $
            IF NOT (IX EQ -1) $
            GOTO LABEL $
            IF NOT (LOW LQ ASTCNT LQ HIGH) $                    "COUNT"
            print error message $                               "COUNT"
```

The comment "COUNT" indicates the statements that were inserted to implement the COUNT option.

7.2.2 BOUNDS

The BOUNDS clause presents a slightly different problem. Now, the validity check must be made within the basic assertion loop and an exit taken if a violation is detected. To provide the exit point, the preprocessor must generate another unique variable name that will be placed immediately following the normal loop exit.

For example, the following is an assertion loop definition with a BOUNDS check and the generated JOVIAL code. All statements inserted for the BOUNDS clause are so marked.

```
            CHAIN (IX) INIT (PTR) NEXT (LINK($IX$)) END (IX EQ -1)
            BOUNDS (LOW...HIGH)
            .
            .
            .
            END CHAIN


            IX = PTR $
        LABEL.
            IF NOT (LOW LQ IX LQ HIGH) $                        "BOUNDS"
            BEGIN                                               "BOUNDS"
               print error message $                            "BOUNDS"
               GOTO ELABEL $                                    "BOUNDS"
            END                                                 "BOUNDS"
            .
            .
            .
            IX = LINK($IX$) $
            IF NOT (IX EQ -1) $
            GOTO LABEL $
        ELABEL.                                                 "BOUNDS"
```

7.2.3 A Complete Example

The following is a complete example designed to show how the code from each of the options; EMPTY, COUNT, and BOUNDS fits together. The JOVIAL statements from each of the options are again marked with comments.

```
    CHAIN (IX) INIT (PTR) NEXT (LINK($IX$)) END (IX EQ -1) EMPTY (PTR EQ -1)
    COUNT (LOCNT...HICNT) BOUNDS (LOBND...HIBND)
    .
    .
    .
    END CHAIN


    IF NOT (PTR EQ -1) $                                          "EMPTY"
    BEGIN
       ASTCNT = Ø $                                               "COUNT"
       IX = PTR $
  LABEL.
       IF NOT (LOBND LQ IX LQ HIBND) $                            "BOUNDS"
       BEGIN                                                      "BOUNDS"
          print error message $                                   "BOUNDS"
          GOTO ELABEL$                                            "BOUNDS"
       END                                                        "BOUNDS"
       ASTCNT = ASTCNT + 1 $                                      "COUNT"
       .
       .
       .
       IX = LINK($IX$) $
       IF NOT (IX EQ -1) $
       GOTO LABEL $
  ELABEL.                                                         "BOUNDS"
       IF NOT (LOCNT LQ ASTCNT LQ HICNT) $                        "COUNT"
       print error message $                                      "COUNT"
    END
```

7.3 Command Stack

In the definition of an assertion loop, all of the loop parameters are specified at the top of the loop. Some of these parameters are used immediately by the preprocessor while others must be saved for usage at the end of the loop. As was discussed previously, assertion loops may be nested several levels deep. This suggests the use of a stack to retain the necessary information for each of the nested loops. Each element of the stack should be a record with fields for the different parameters to be retained. The following are the parameters that must be retained for a JOVIAL implementation as we have thus far described it.

1) Index variable
2) Algebraic expression for the next value of the index variable
3) Boolean condition that indicates exit from the loop
4) Label at the head of the loop
5) Label at the exit from the loop (optional entry-used with BOUNDS clause)
6) Legal range for record count (optional entry-used with COUNT clause)

7.4 JOVIAL Automated Verification System (JAVS)

The current version of JAVS provides the programmer with some assertion statements for use with Boolean expressions. We feel that the inclusion of our new assertion constructs, along with the Stucki-like VALUE assertion, would make JAVS a much more powerful system development and maintenance tool. Thus, we explored the feasibility of modifying JAVS to this means. First, it was decided that the set of directives recognized by JAVS could be easily expanded to suit our needs. And just as importantly, it was determined that JAVS already contained general statement parsing and text-manipulation routines to facilitate implementation of the new directives. None of the existing software would need to be changed, only new code added. The following sections briefly describe the modification work done on JAVS. (More detailed documentation and the modified JAVS source listing can be found in Appendices III and IV).

7.4.1 JAVS Directives

JAVS directives are statements which may be included in a JOVIAL source text but are only meaningful to the JAVS preprocessor. Some of these directives, such as JAVSTEXT, are used for naming and organizing various parts of a large software system. Others, the computational directives, cause JOVIAL code to be generated and inserted into the probe text. It is this subset that we are interested in expanding.

All the JAVS directives are written in the following basic format:

".⟨JAVS-directive⟩⟨any necessary parameters⟩"

with the character strings ". and " serving as directive delimiters. The choice of these symbols as delimiters insures that the directives can be left in the source code and will be interpreted as comments by the JOCIT compiler. (Double quotes (") serve as the JOVIAL comment delimiter.)

For our new assertion constructs, we added these four new JAVS computational directives: CHAIN, ENDCHAIN, LOOP and ENDLOOP. Each directive statement was given the appropriate syntax as defined previously. For instance, the LOOP directive syntax is as follows:

".LOOP (⟨variable name⟩) (⟨range⟩) [EMPTY (⟨boolean expression⟩)]

We also saw a need to expand the simple assertion power of JAVS as outlined in Section 6.0. In that section, we defined the following three formats for simple assertions.

ASSERT (⟨boolean expression⟩)
ASSERT VALUE (⟨variable name⟩) (⟨list of legal values and/or ranges⟩)
ASSERT VALUE (⟨variable name⟩) NOT (⟨list of illegal values and/or ranges⟩)

JAVS already supports an assertion directive of the following form

".ASSERT, ⟨JOVIAL boolean expression⟩".

We decided to retain this syntax for the expression assertion in order that all old JOVIAL software would be upward compatible with the new JAVS system. Then, for the other two value assertions, we have added a VALUE directive with the following syntax.

".VALUE (⟨variable name⟩) [NOT] (⟨list of values and/or ranges⟩)"

In summary, we made a total of five additions to the set of computational directives that JAVS recognizes. Four of these are to support our new assertion constructs and the fifth is an enhancement to the simple assertion power of JAVS. A complete listing of the assertion directives recognized by the enhanced version of JAVS can be found in Appendix I.

7.4.2 Directive Code Modifications

Our first task was to make the JAVS source text analyzer recognize the new directives that we wished to add. This was a simple job. Procedure LOOK in component JAVS-2 contains a table, L1, of all the JAVS directives. We had to increment the table size by 5 (definition of NJDIR) and add entries for the new directives and their lengths to table L1.

The remainder of the modifications had to be made in component JAVS-5, the module instrumentation component. Procedure PRBDIR is the routine that is called each time a directive is encountered in the instrumentation phase. PRBDIR had to have additions made to it so that when any of the five new directives are encountered, it invokes the correct procedures.

New procedures had to be written for the directives CHAIN, ENDCHAIN, LOOP and VALUE. Since we decided to translate the LOOP directive into code similar to that for CHAIN (no FOR loop), we are able to use the ENDCHAIN procedure for both the ENDCHAIN and ENDLOOP directives. Each of these new routines was written in the style of the older directive routines, relying heavily on the already existing support routines of components JAVS-2, JAVS-5 and JAVS-11.

The compool for the JAVS-5 component also had to be updated. Procedure templates were added for each of the new procedures and for BALPAR, a JAVS-11 routine that had not previously been called from the JAVS-5 component. A common area, ASSERT, was also added to the compool. Its major contents are the stack and stack pointer for processing the assertion loops. It also contains a flag, DCLASSCNT, which indicates whether or not the variable ASSCNT (used for checking record count assertions) has yet been defined.

Like statements written in any other language, it is certainly possible for these assertion statements to be incorrectly written. For instance, the NEXT field might be missing in a CHAIN directive statement. Or, there might be an imbalance between the number of LOOP and ENDLOOP statements. Checks have been included in all the assertion procedures to detect these types of mistakes. In the event of such an error, the JAVS-11 ERROR procedure is invoked with an explanatory message. Appendix II contains a complete list of these error diagnostic messages.

7.4.3 Assertion-Violation Output

JAVS uses a scheme based on the JOCIT compiler's MONITOR primitive for outputting assertion-violation messages. This was done to add another level of user control to the activation of the assertions. The violation output can be turned off at compile time independent of the output from the JAVS structural instrumentation [17].

To us, this scheme does not seem entirely satisfactory. The first problem is that it ties the assertion facility to the monitoring task. One can never have the assertions enabled without also having the monitors activated. Thus it is not possible to get any occasional assertion violation output without also getting the possibly voluminous monitor output. And to make matters even worse, output from both sources goes to the same output file.

However, the major problem is that under this scheme, the output messages must be fixed at the time of structural instrumentation. It is not possible to output the execution-time values of the pertinent variables along with a violation message. The programmer is virtually left in the dark when it comes to locating the cause of the violation. He is not given even the slightest bit of information from which to start his search.

We feel that a more powerful and flexible output scheme could be used by sacrificing the compile-time control. Instead of using the MONITOR capability, standard JOVIAL output statements could be inserted into the probe text. These statements would output the appropriate explanatory message and any pertinent variable values for each violation.

However, in keeping with our desire not to alter any of the existing JAVS system, we will retain the MONITOR scheme for use with our new assertions.

8. CONCLUSION

In this report we discussed the contributions that dynamic monitoring can make in the area of software maintenance. Assertions provide documentation that can help the maintenance programmer avoid modification errors. The assertions also assist in the detection of any errors that are introduced during modification. These benefits were previously not recognized since the initial work on dynamic monitoring had been done from a software reliability perspective.

The main thrust of the results presented in this report is the expansion of the already existing assertion concepts to include array data structures which have been virtually ignored in all previous work. Initially we developed a record-oriented approach toward array data structures. Based on this approach we proposed an assertion technique that will enable effective monitoring of most linear-list data structures that have been implemented as JAVS tables or arrays. We believe this is a big step in the development of monitoring as an effective software-development tool.

Finally, we discussed some important considerations relative to the implementation of our new assertion concepts for a JOVIAL system. As demonstration, modifications were made to JAVS so that it could serve as the preprocessor for an expanded assertion language containing our new constructs. Appendix V contains the output listing of an example run of this modified version of JAVS.

More research is needed to study the use and benefits of dynamic monitoring throughout the whole software life cycle. We need to determine how easily assumptions and decisions can be defined and explicitly stated when designing software. Then, how many of these can effective assertions be written for? Assertions appear to be a promising tool for detecting errors made during software modification, but we need to research this area more. We must determine what kind of errors are typically made and how effective this type of dynamic monitoring will be in detecting them. Our belief is that dynamic monitoring will indeed be an effective and powerful tool over the whole software life cycle.

9. REFERENCES

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APPENDIX I

JAVS Assertion Directives

```
".ASSERT, ⟨boolean expr.⟩"

".VALUE (⟨variable name⟩) [NOT] (⟨list of values and/or ranges⟩)"

".LOOP (⟨variable name⟩) (⟨range⟩) [EMPTY (⟨boolean expr.⟩)]

".ENDLOOP"

".CHAIN (⟨variable name⟩) INIT (⟨arith. expr.⟩) NEXT (⟨arith. expr.⟩) END

   (⟨boolean expr.⟩) [EMPTY (⟨boolean expr.⟩)] [BOUNDS (⟨range⟩)] [COUNT

   (⟨range⟩) ]"

".ENDCHAIN"
```

APPENDIX II

Error Diagnostic Messages

This appendix describes the error diagnostic messages that JAVS generates as a result of improperly specified assertion directives. The standard JAVS ERROR procedure is used to output these messages to the JAVS output report. Given here with each error message is a brief explanation of the probable cause of the error and in what procedure it was detected.

ASSERTION STACK OVERFLOW

> There is an overflow condition on the assertion command stack. The number of nested LOOP and CHAIN directives exceeds the permissable limit. This limit is defined as MAXCSTK (= 1Ø) in procedures PRBCHAIN and PRBLOOP and in common ASSERT. Error detected in procedure PRBCHAIN or PRBLOOP.

ASSERTION STACK UNDERFLOW

> There is an underflow condition on the assertion command stack. For the ENDLOOP or ENDCHAIN directive being processed, there has been no matching LOOP or CHAIN directive. Error detected in procedure PRBENDC.

CHAIN ASSERTION ERROR - NO INIT FIELD

> No INIT field specified for a CHAIN assertion directive. Error detected in procedure PRBCHAIN.

CHAIN ASSERTION ERROR - NO NEXT FIELD

> No NEXT field specified for a CHAIN assertion directive. Error detected in procedure PRBCHAIN.

CHAIN ASSERTION ERROR - NO END FIELD

> No END field specified for a CHAIN assertion directive. Error detected in procedure PRBCHAIN.

APPENDIX III

JAVS Modification Documentation

A. JOVIAL Automated Verification System
Documentation of changes made to JAVS to implement an expanded assertion specification language.

B. Work done at Northwestern University
by John L. Ramey
(312) 492-5248

Sponsored by Rome Air Development Center
Under Contract No. F30602-76-C-0397
Project Engineer - Mr. R. Iuorno

C. Abstract
This work is a modification to JAVS to enhance its dynamic assertion capabilities. More computational directives were added to the set that JAVS recognizes. These new directives give JAVS more assertion power both for simple data items and most linear list data structures. New routines were added to translate these assertions into the proper JOVIAL code during the instrumentation phase. All the source code was written in JOVIAL and tested on a HONEYWELL 6180.

D. Computer definition
The hardware requirements are the same as for the unmodified JAVS.

E. System Description
The modifications were run successfully under the H6180/GCOS Version H.1 operating system. No new special executive software is required.

F. Program Description
The general philosophy used when making the modifications was to use the same basic approaches to the organization and coding as were done in the original version of JAVS. All new routines were written using the same style as the older ones and previously written support routines were used whenever possible. Only enhancements were made so that all previously written programs and JAVS directives still work under the modified version. As was done with the previous directives, they are all recognized in the initial basic analysis of phase 2. Then during the instrumentation phase, routine PRBDIR distinguishes between the various possible directives calling the correct routine to handle each.

JPROBE - modified procedure in JAVS-5
An addition was made to this procedure so that it initialized both the assertion command stack pointer (CSTKPTR) and the variable indicating whether or not the count variable had yet been declared (DCLASSCNT).

LOOK - modified procedure in JAVS-2

Additions were made to the directive table in this procedure so that the five additional directives would be recognized during the basic analysis phase.

PRBAST - modified procedure in JAVS-5
This procedure was modified to make use of the new procedure PRBDCL instead of doing the same tasks internally.

PRBCHAIN - new procedure in JAVS-5
This procedure handles the CHAIN assertion directive. For each directive, it generates the required JOVIAL code for the top of the assertion loop and saves the necessary information on the top of the assertion command stack for use when the matching ENDCHAIN directive is encountered.

PRBCHKL - new procedure in JAVS-5
This procedure is used to keep from overflowing the TXTBUF buffer when building statements. Whenever there is a possibility that a new addition might not fit in the buffer, PRBCHKL is called before ADDTXT. If it will not fit, the contents of the buffer are written out as a statement and the buffer is cleared.

PRBDCL - new procedure in JAVS-5
This procedure makes sure that the MONITOR function is turned on for outputting violations from the assertions.

PRBDIR - modified procedure in JAVS-5
Additional entries were made to the IFEITHER statement in this routine so that when the new directives were encountered during the instrumentation phase, the appropriate procedures would be called.

PRBENDC - new procedure in JAVS-5
This procedure handles both the ENDCHAIN and the ENDLOOP directives. It gets the information from the record on top of the assertion command stack and generates the JOVIAL statements necessary for the termination of the assertion loop.

PRBLBL - new procedure in JAVS-5
This procedure generates a six-digit label based on the current statement number. Called by PRBCHAIN and PRBLOOP.

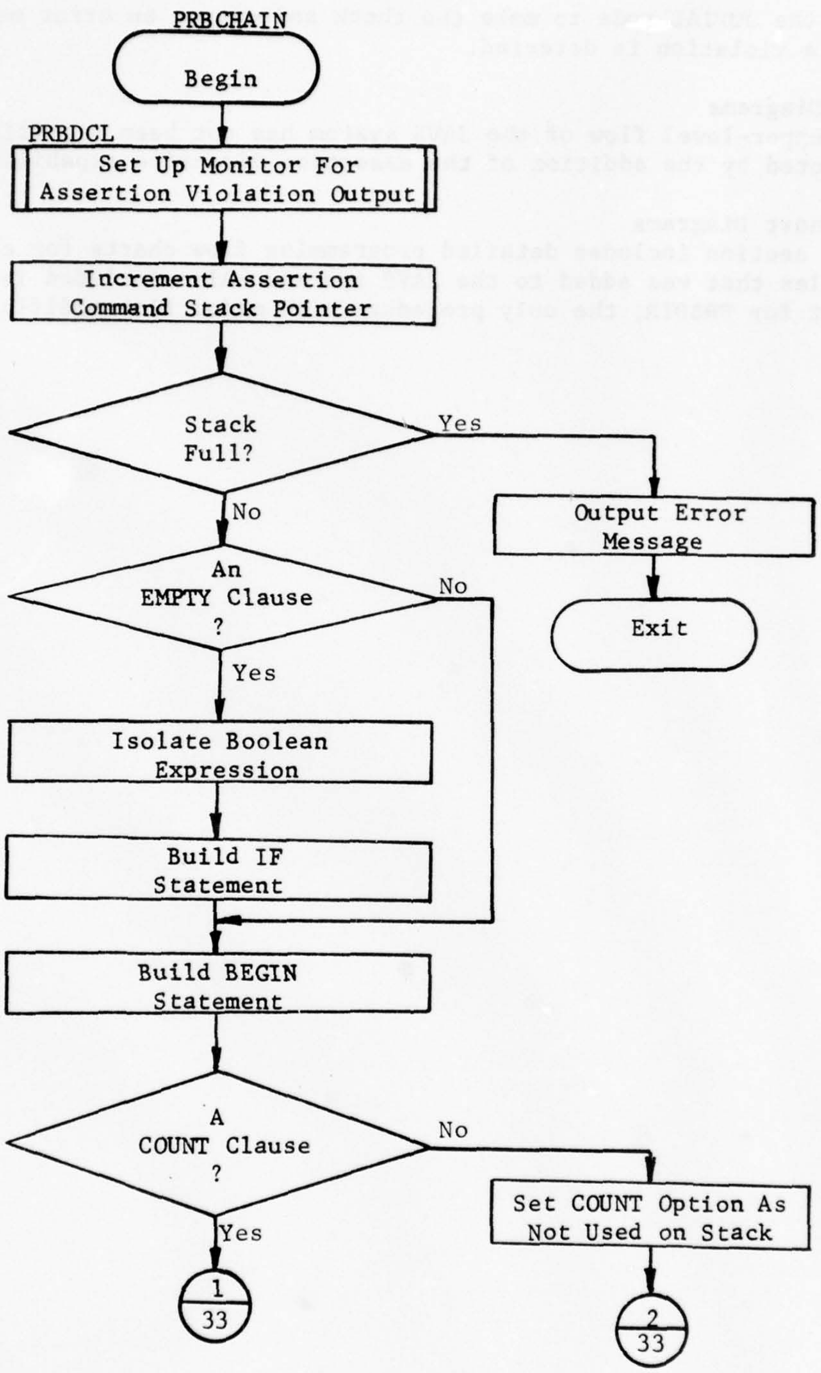
PRBLOOP - new procedure in JAVS-5
This procedure handles the LOOP assertion directive. For each directive, it generates the required JOVIAL code for the top of the assertion loop and saves the necessary information on the top of the assertion command stack for use when the matching ENDLOOP directive is encountered.

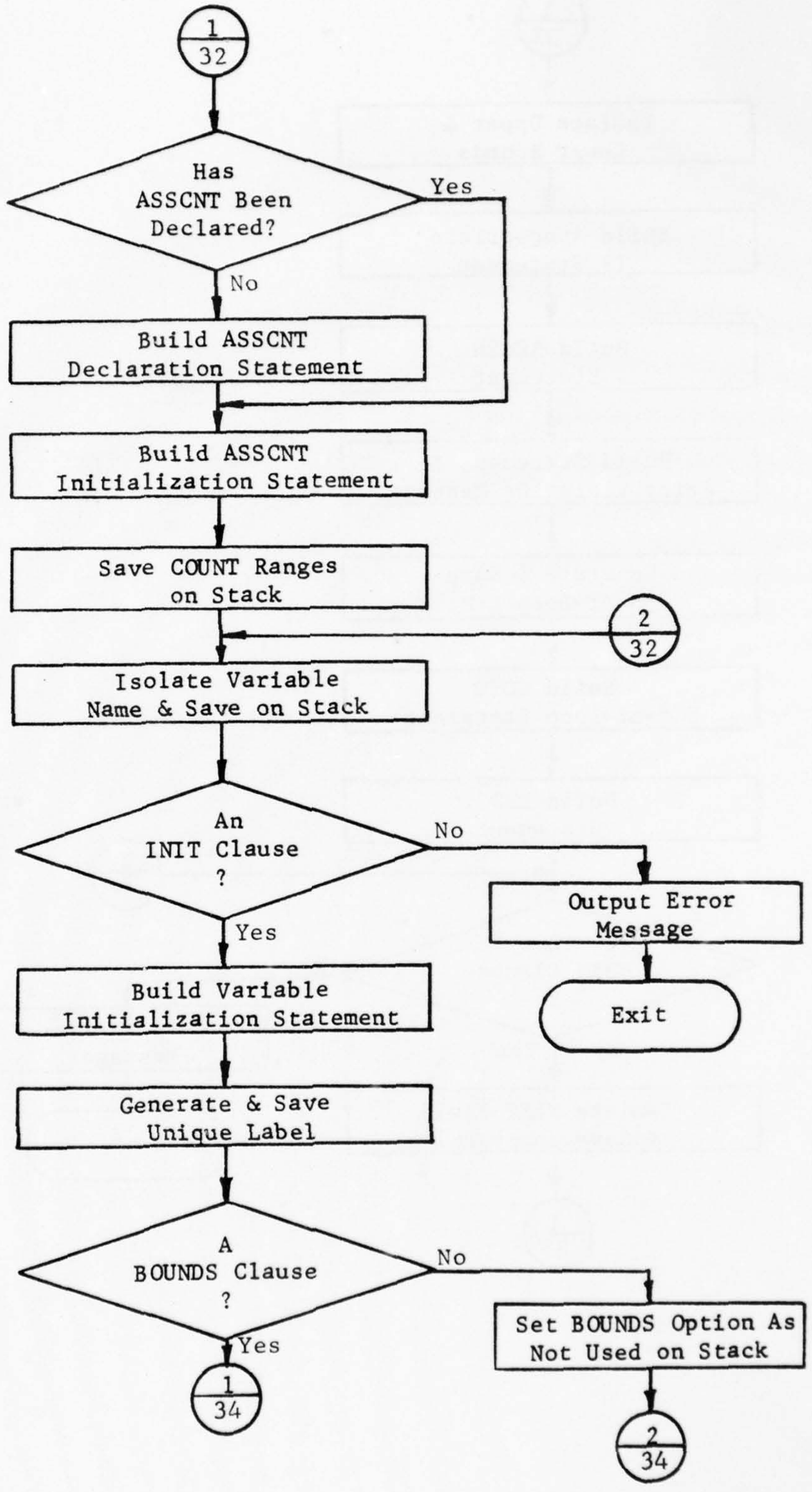
PRBVALUE - new procedure in JAVS-5
This procedure handles the VALUE assertions. It extracts the variable name and values from the assertion directive and generates

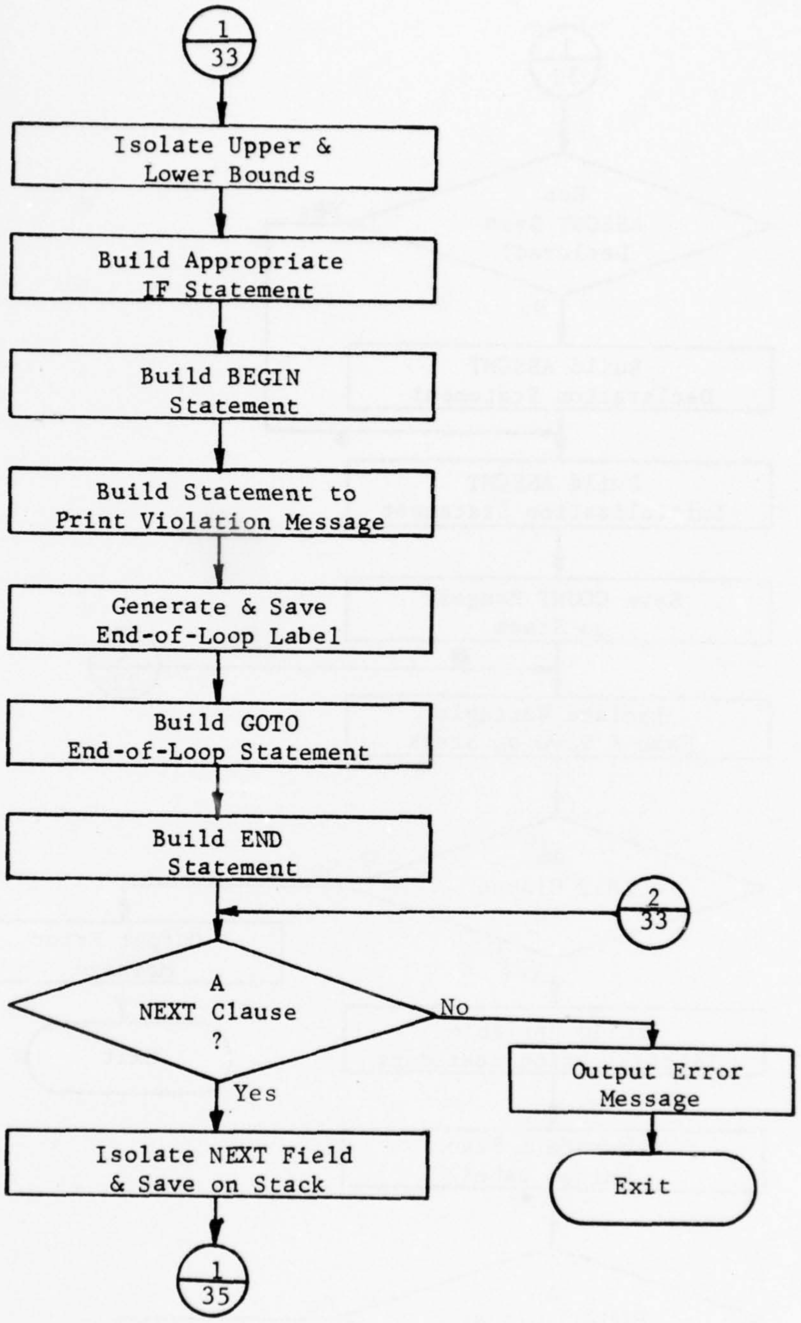
the JOVIAL code to make the check and output an error message if a violation is detected.

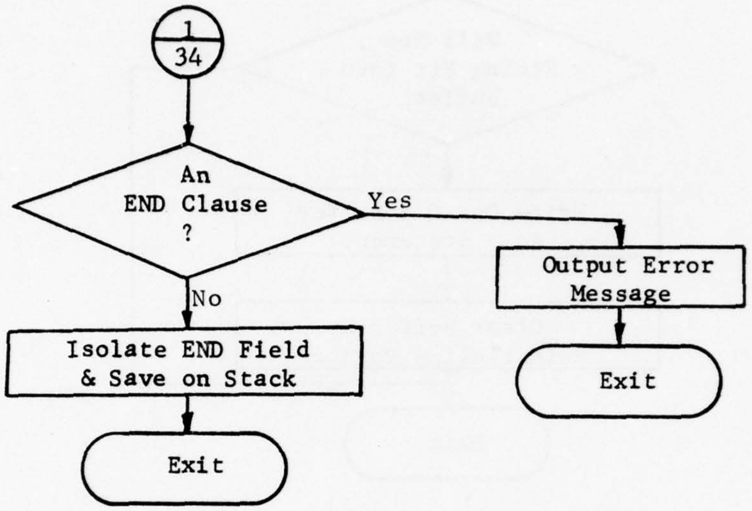
G. **Logic Diagrams**
The upper-level flow of the JAVS system has not been significantly affected by the addition of the assertion directive capabilities.

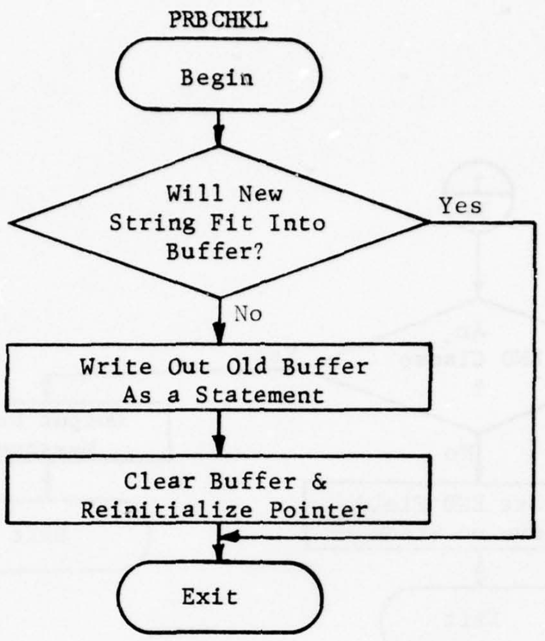
H. **Flow Chart Diagrams**
This section includes detailed programming flow charts for each of the modules that was added to the JAVS system. Also included is the flow chart for PRBDIR, the only procedure with major flow modifications.

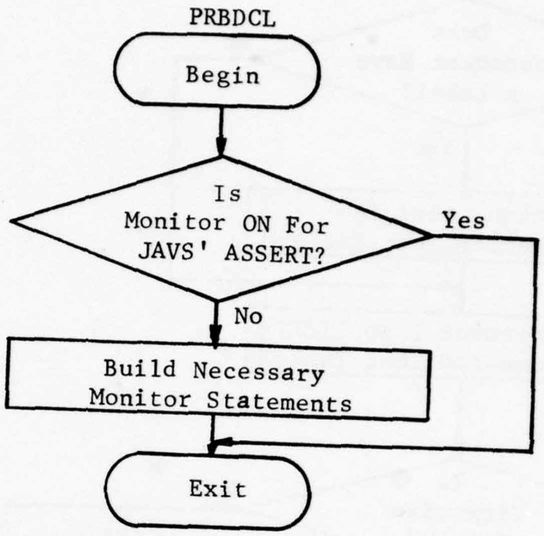

PRBCHAIN
Begin
PRBDCL
Set Up Monitor For Assertion Violation Output
Increment Assertion Command Stack Pointer
Stack Full?
Yes
No
Output Error Message
Exit
An EMPTY Clause ?
No
Yes
Isolate Boolean Expression
Build IF Statement
Build BEGIN Statement
A COUNT Clause ?
No
Yes
Set COUNT Option As Not Used on Stack
1/33
2/33

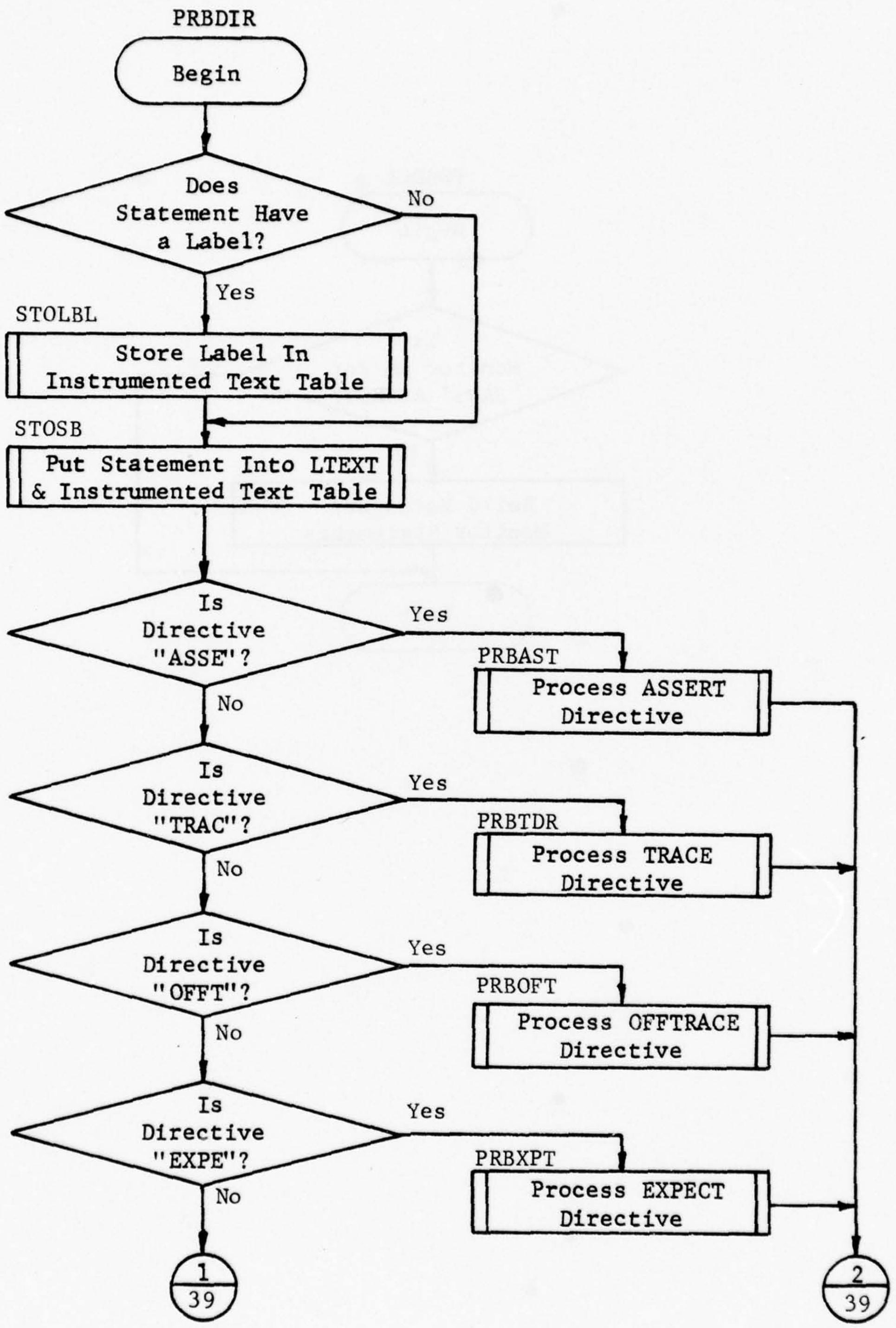

1 / 32
Has ASSCNT Been Declared?
Yes
No
Build ASSCNT Declaration Statement
Build ASSCNT Initialization Statement
Save COUNT Ranges on Stack
2 / 32
Isolate Variable Name & Save on Stack
An INIT Clause ?
No
Output Error Message
Exit
Yes
Build Variable Initialization Statement
Generate & Save Unique Label
A BOUNDS Clause ?
No
Set BOUNDS Option As Not Used on Stack
Yes
1 / 34
2 / 34

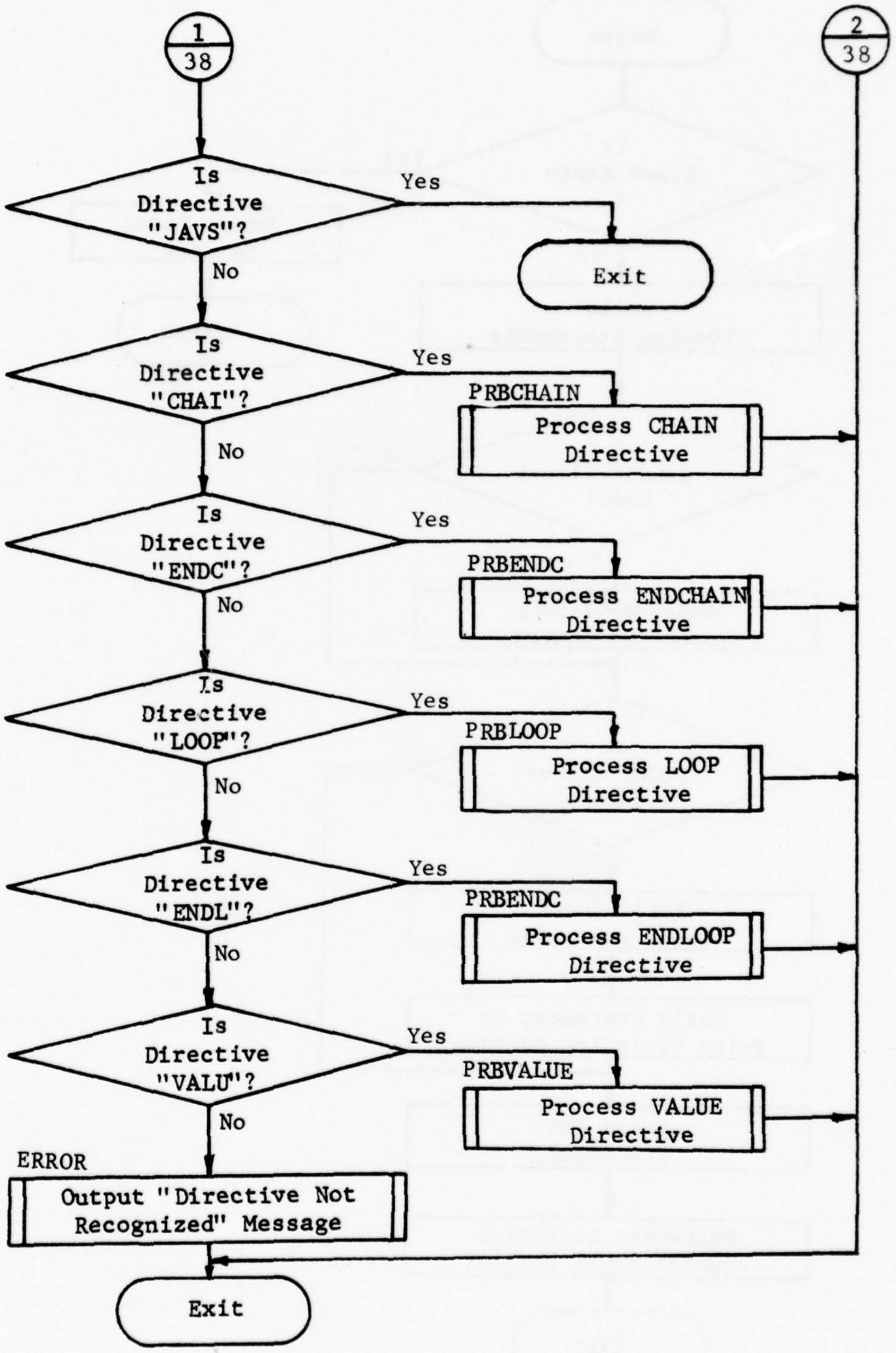

1
33
Isolate Upper & Lower Bounds
Build Appropriate IF Statement
Build BEGIN Statement
Build Statement to Print Violation Message
Generate & Save End-of-Loop Label
Build GOTO End-of-Loop Statement
Build END Statement
2
33
A NEXT Clause ?
No
Yes
Output Error Message
Exit
Isolate NEXT Field & Save on Stack
1
35

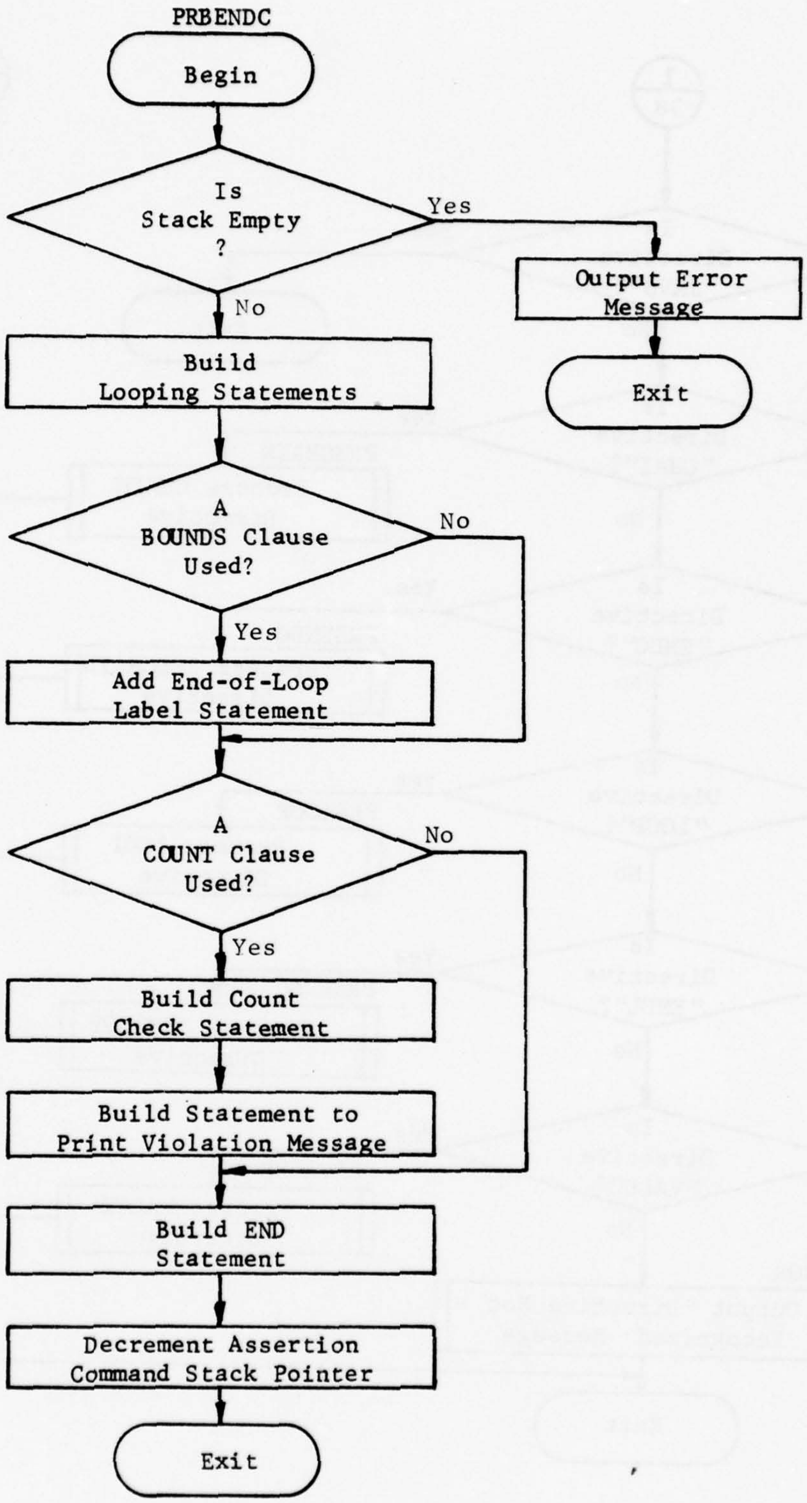

1
34
An END Clause ?
Yes
No
Output Error Message
Exit
Isolate END Field & Save on Stack
Exit

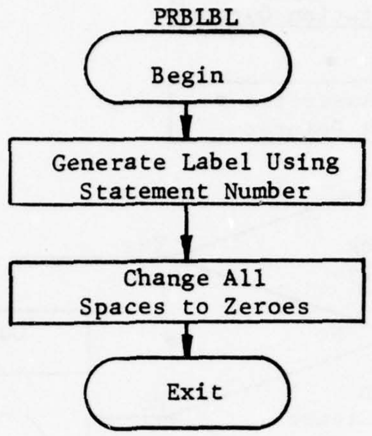

PRBCHKL
Begin
Will New String Fit Into Buffer?
Yes
No
Write Out Old Buffer As a Statement
Clear Buffer & Reinitialize Pointer
Exit

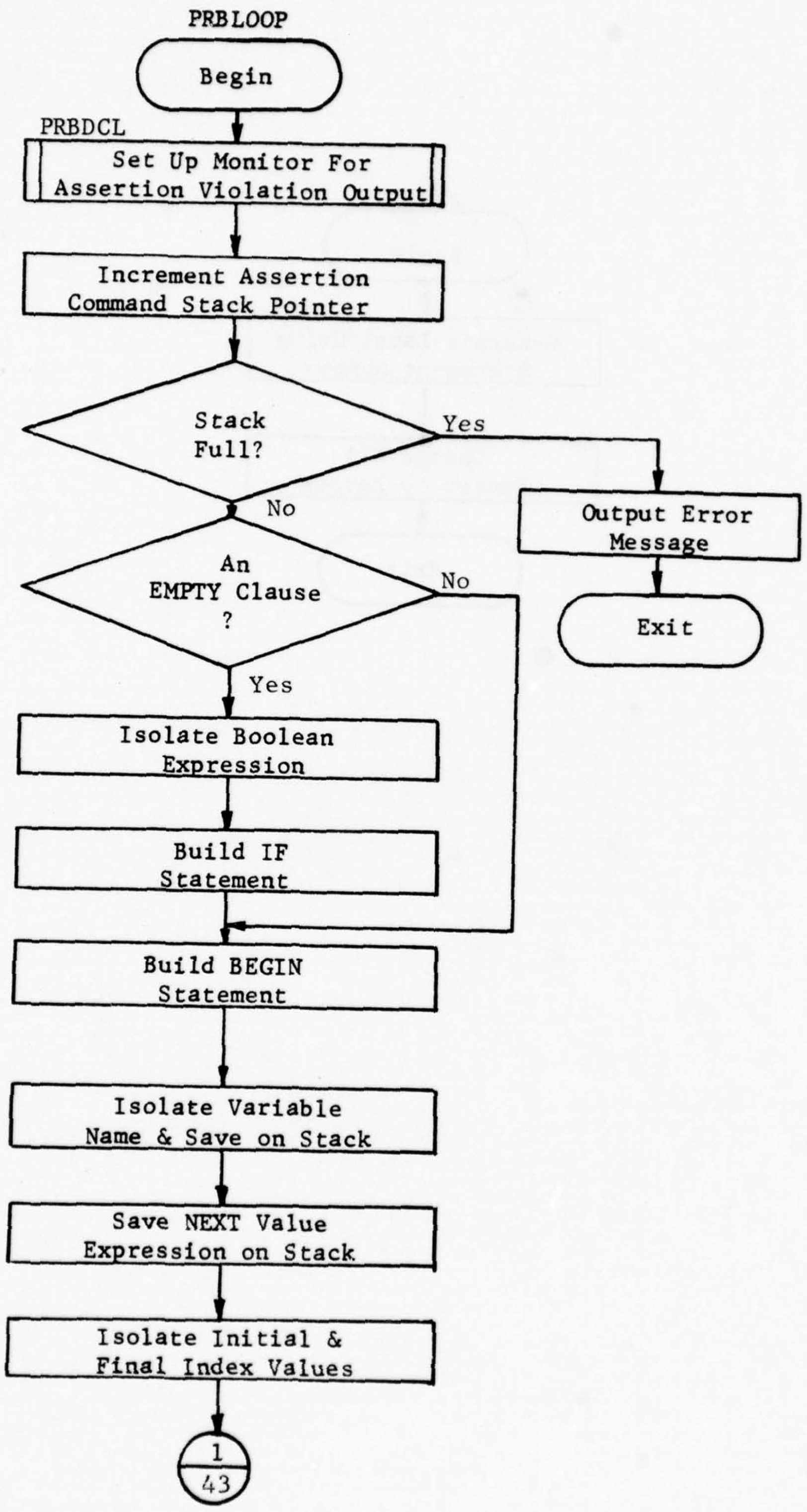

PRBDCL
Begin
Is Monitor ON For JAVS' ASSERT?
Yes
No
Build Necessary Monitor Statements
Exit

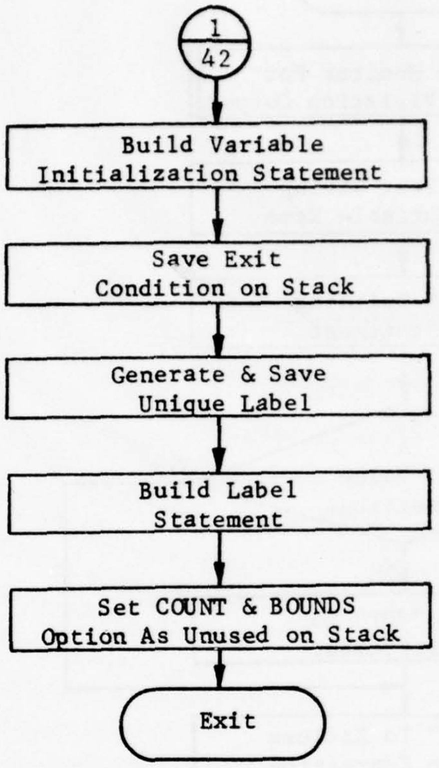

PRBDIR
Begin
Does Statement Have a Label?
No
Yes
STOLBL
Store Label In Instrumented Text Table
STOSB
Put Statement Into LTEXT & Instrumented Text Table
Is Directive "ASSE"?
Yes
PRBAST
Process ASSERT Directive
No
Is Directive "TRAC"?
Yes
PRBTDR
Process TRACE Directive
No
Is Directive "OFFT"?
Yes
PRBOFT
Process OFFTRACE Directive
No
Is Directive "EXPE"?
Yes
PRBXPT
Process EXPECT Directive
No
1/39
2/39

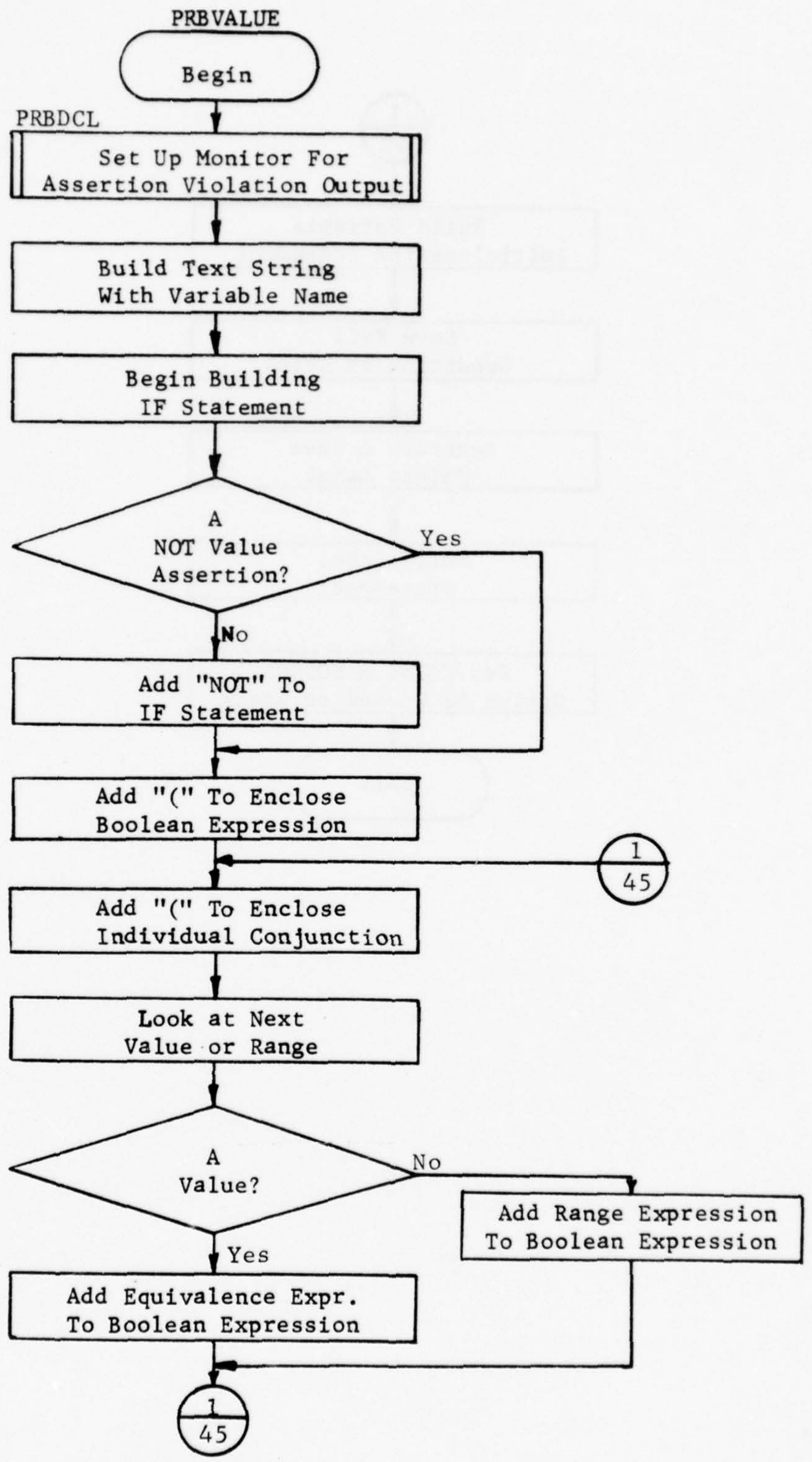

1/38
2/38
Is Directive "JAVS"?
Yes
Exit
No
Is Directive "CHAI"?
Yes
PRBCHAIN
Process CHAIN Directive
No
Is Directive "ENDC"?
Yes
PRBENDC
Process ENDCHAIN Directive
No
Is Directive "LOOP"?
Yes
PRBLOOP
Process LOOP Directive
No
Is Directive "ENDL"?
Yes
PRBENDC
Process ENDLOOP Directive
No
Is Directive "VALU"?
Yes
PRBVALUE
Process VALUE Directive
No
ERROR
Output "Directive Not Recognized" Message
Exit

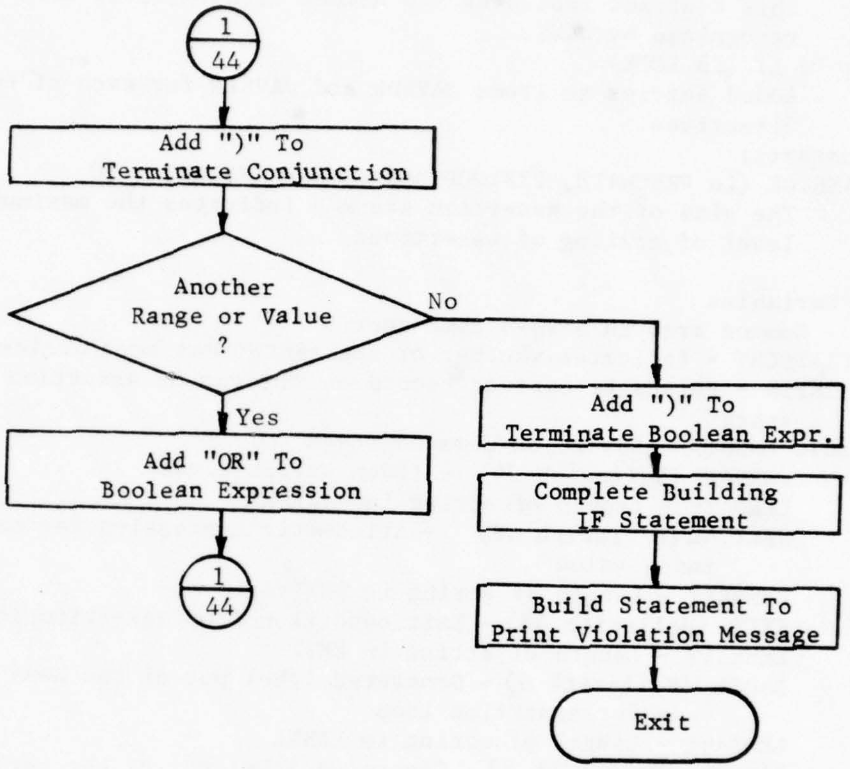

PRBENDC
Begin
Is Stack Empty ?
Yes
Output Error Message
Exit
No
Build Looping Statements
A BOUNDS Clause Used?
No
Yes
Add End-of-Loop Label Statement
A COUNT Clause Used?
No
Yes
Build Count Check Statement
Build Statement to Print Violation Message
Build END Statement
Decrement Assertion Command Stack Pointer
Exit


PRBLBL
Begin
Generate Label Using Statement Number
Change All Spaces to Zeroes
Exit


PRBLOOP
Begin
PRBDCL
Set Up Monitor For Assertion Violation Output
Increment Assertion Command Stack Pointer
Stack Full?
Yes
No
Output Error Message
Exit
An EMPTY Clause ?
No
Yes
Isolate Boolean Expression
Build IF Statement
Build BEGIN Statement
Isolate Variable Name & Save on Stack
Save NEXT Value Expression on Stack
Isolate Initial & Final Index Values
1
43


1
42
Build Variable Initialization Statement
Save Exit Condition on Stack
Generate & Save Unique Label
Build Label Statement
Set COUNT & BOUNDS Option As Unused on Stack
Exit


PRBVALUE
Begin
PRBDCL
Set Up Monitor For Assertion Violation Output
Build Text String With Variable Name
Begin Building IF Statement
A NOT Value Assertion?
Yes
No
Add "NOT" To IF Statement
Add "(" To Enclose Boolean Expression
1/45
Add "(" To Enclose Individual Conjunction
Look at Next Value or Range
A Value?
No
Add Range Expression To Boolean Expression
Yes
Add Equivalence Expr. To Boolean Expression
1/45


1
44
Add ")" To Terminate Conjunction
Another Range or Value ?
No
Yes
Add "OR" To Boolean Expression
1
44
Add ")" To Terminate Boolean Expr.
Complete Building IF Statement
Build Statement To Print Violation Message
Exit

I. Program Constants

Modified constants:

- NJDIR (in LOOK) - changed from 11 to 16
  - This constant indicates the number of directives that are recognized by JAVS.
- Table L1 (in LOOK)
  - Added entries to items JAVSDR and JAVSLN for each of the new directives.

New constants:

- MAXSTCK (in PRBCHAIN, PRBLOOP and common ASSERT) = 10
  - The size of the assertion stack - indicates the maximum level of nesting of assertions

J. Program Variables

ASSERT - Common area in JAVS-5 component

- DCLASSCNT - Indicates whether or not ASSCNT has been declared yet
- CSTKPTR - Points to current record on the top of assertion command stack
- Table CMDSTK - Assertion Command Stack
  - VARNAME (Hollerith 24) - Index variable name
  - LENNAME - Length of string in VARNAME
  - NEXTVAL (Hollerith 48) - Arithmetic expression for next index value
  - LENNEXT - Length of string in NEXTVAL
  - EXIT (Hollerith 48) - Exit condition from assertion loop
  - LENEXIT - Length of string in EXIT
  - LABEL (Hollerith 6) - Generated label put at the head of JOVIAL code for assertion loop
  - LENLABL - Length of string in LABEL
  - ELABEL (Hollerith 6) - Generated label put at the termination of JOVIAL code for assertion loop
  - LENELBL - Length of string in ELABEL
  - MINCNT (Hollerith 24) - Minimum of record COUNT range
  - LENMIN - Length of string in MINCNT
  - MAXCNT (Hollerith 24) - Maximum of record COUNT range
  - LENMAX - Length of string in MAXCNT

PRBCHAIN (MODULE, STMT) - Procedure in JAVS-5 component

- ASSLEN - Holds the length of the string in ASSTXT
- ASSTXT - String buffer used used for strings that are built from entries in the current statement block
- FROM - Marks a position in the current SB.
  Usually used for an opening parenthesis
- KEYWRD - Marks a position in the current SB.
  Used for marking various keywords
- MIDL - Marks a position in the current SB.
  Usually used for the range operator
- MODULE - Number of the currently active module
- STMT - Number of the current statement
- TO - Marks a position in the current SB.
  Usually used for the closing parenthesis

TMPTXT - Used as a temporary string buffer when calling routines
JUSTRT and LASTCH to determine the length of the string
in ASSTXT

TXTPTR - Contains the character count for the statement being
built in TXTBUF

PRBCHKL (MODULE, CHARS, LENGTH = NEW'LENGTH) - Procedure in JAVS-5
component

CHARS - Length of string to be added to TXTBUF

LENGTH - Length of current string in TXTBUF

MODULE - Number of the currently active module

NEW'LENGTH - Length of the string in TXTBUF at termination of
PRBCHKL

PRBDCL - Procedure in JAVS-5 component

No local variables

PRBENDC (MODULE, STMT) - Procedure in JAVS-5 component

ASSLEN - Holds the length of the string in ASSTXT

ASSTXT - String buffer used for strings that are built from entries
in the current statement block

MODULE - Number of the currently active module

STMT - Number of the current statement

TXTPTR - Contains the character count for the statement being
built in TXTBUF

PRBLBL (STMT, NO = LABEL) - Procedure in JAVS-5 component

LABEL - String buffer (length = 6) for newly generated label

NO - One digit used as the sixth character of the label

STMT - Number of the current statement

PRBLOOP (MODULE, STMT) - Procedure in JAVS-5 component

ASSLEN - Holds the length of the string in ASSTXT

ASSTXT - String buffer used for strings that are
built from entries in the current statement block

FROM - Marks a position in the current SB.
Usually used for an opening parenthesis

KEYWRD - Marks a position in the current SB.
Used for marking various keywords

MIDL - Marks a position in the current SB.
Usually used for the range operator

MODULE - Number of the currently active module

STMT - Number of the current statement

TO - Marks a position in the current SB.
Usually used for the closing parenthesis

TXTPTR - Contains the character count for the
statement being built in TXTBUF

VARLEN - Holds the length of the string in VARTXT

VARTXT - String buffer that is used to save the
variable name that is extracted from the assertion

PRBVALUE (MODULE, STMT) - Procedure in JAVS-5 component

ASSLEN - Holds the length of the string in ASSTXT
ASSTXT - String buffer used for strings that are
    built from entries in the current statement block
FROM - Marks a position in the current SB.
    Usually used for an opening parenthesis
MIDL - Marks a position in the current SB.
    Usually used for the range operator
MODULE - Number of the currently active module
RPAREN - Marks the position of the right
    parenthesis surrounding the list of values
    in the assertion
STMT - Number of the current statement
TO - Marks a position in the current SB.
    Usually used for the closing parenthesis
TXTPTR - Contains the character count for the
    statement being built in TXTBUF
VARLEN - Holds the length of the string in VARTXT
VARTXT - String buffer that is used to save the
    variable name that is extracted from the assertion

K. Inputs

All inputs are in the same form as before. All inputs that were previously recognized are still valid. The effect of this modification has been to expand the set of directives that JAVS would accept as input. The new JAVS directives that are acceptable as input have syntaxes as defined below:

".CHAIN (⟨variable name⟩) INIT (⟨arith. expr.⟩) NEXT (⟨arith. expr.⟩) END (⟨boolean expr.⟩) [EMPTY (⟨boolean expr.⟩)] [BOUNDS (⟨range⟩)] [COUNT (⟨range⟩)]"

".ENDCHAIN"

".ENDLOOP"

".LOOP (⟨variable name⟩) (⟨range⟩) [EMPTY (⟨boolean expr.⟩)]"

".VALUE (⟨variable name⟩) [NOT] (⟨list of values and/or ranges⟩)"

L. Output

All output generated by the additions to JAVS takes the form of that which is generated by the unmodified version of JAVS. Like the original JAVS computational directives, each new assertion directive causes the generation of JOVIAL code which is inserted into the probed text. All error diagnostics are output using the standard ERROR procedure so their form is also consistent with that of the error messages of the unmodified JAVS.

M. Error Messages

ASSERTION STACK OVERFLOW

There is an overflow condition on the assertion command stack. The number of nested LOOP and CHAIN directives exceeds the permissable limit. This limit is defined as MAXCSTK (=10) in procedures PRBCHAIN and PRBLOOP and in common ASSERT. Error detected in procedure PRBCHAIN or PRBLOOP.

ASSERTION STACK UNDERFLOW

There is an underflow condition on the assertion command stack. For the ENDLOOP or ENDCHAIN directive being processed, there has been no matching LOOP or CHAIN directive. Error detected in procedure PRBENDC.

CHAIN ASSERTION ERROR - NO END FIELD

No END field specified for a CHAIN assertion directive. Error detected in procedure PRBCHAIN.

CHAIN ASSERTION ERROR - NO INIT FIELD

No INIT field specified for a CHAIN assertion directive. Error detected in procedure PRBCHAIN.

CHAIN ASSERTION ERROR - NO NEXT FIELD

No NEXT field specified for a CHAIN assertion directive. Error detected in procedure PRBCHAIN.

N. Operating Instructions

There are no new special operating instructions to go with these modifications.

APPENDIX IV

JAVS Modification Listings

This section contains the partial compilation listings for the modified version of JAVS. JAVS is a large system which contains several hundred different modules. It is therefore impossible to include here the listings for each of those modules. What is included are listings for every new procedure and every procedure that was modified. The listing of the compool that contains the added common area is also included. For a description of the other modules in the system, refer to [17].

```
20762 02  05-03-78   10.422     JOVIAL COMPILATION OF LOOK           JOCIT VERSION 042275              PAGE      1

   ALTER NO       ****5****1****5****2****5****3****5****4****5****5****5****6****5****7****5****8                 AN21

              ''.JAVSTEXT LOOK COMPUTE (J2P) = JAVS2 EXECUTABLE MODULES ''
               START
              PROC LOOK $                        ''PROCEDURE WHICH GETS NEXT PART
                                                   OF SPEECH''
                   .'      JAVS-2 COMPONENT        ''
              ''.GROUP J2SB = STATEMENT AND STATEMENT DESCRIPTOR BLOCK CONSTRUCTION''
              ''.PROCESS SCANTEXT=JOVIAL SYMBOL ANALYSIS''
                          ''THIS PROCEDURE REPLACES THE ORIGINAL LOOK WHICH
                           IS RENAMED OLOOK.  RATHER THAN INSERT CODE AFTER
                           EACH CALL TO LOOK, WE DID IT THIS WAY TO MINIMIZE
                           THE NUMBER OF CHANGES.''
              DEFINE COMBP  ''G2DICT(908)  ''  $
              DEFINE NJDIR ''16'' ''NUMBER OF JAVS DIRECTIVES'' $
              ITEM T1 N 6 $
                     DEFINE INTG '' I 24 S '' $
                     DEFINE NLL '' N 4 '' $
              ITEM T2 INTG $
              TABLE L1 R NJDIR $ 2 $
                BEGIN
                ITEM JAVSDR T 6 0 0  $
                  BEGIN
                  6T(ASSERT)
                  6T(EXPECT)
                  6T(TOLERA)
                  6T(TRACE )
                  6T(OFFTRA)
                  6T(JAVSTE)
                  6T(GROUP )
                  6T(PROCES)
                  6T(FUNCTI)
                  6T(CLASS )
                  6T(CONTRO)
                  6T(LOOP  )           ''LOOP DIRECTIVE -- JLR, 2/16/78''
                  6T(ENDLOO)           ''ENDLOOP DIRECTIVE -- JLR, 2/16/78''
                  6T(CHAIN )           ''CHAIN DIRECTIVE -- JLR, 2/28/78''
                  6T(ENDCHA)           ''ENDCHAIN DIRECTIVE -- JLR, 2/28/78''
                  6T(VALUE )           ''VALUE DIRECTIVE -- JLR, 3/21/78''
                  END
                ITEM JAVSLN I 24 U 1 0  $
                  BEGIN
                        6 6 9 5
                  8
              8 5 7 8 5 7
                4  ''LOOP''
                7  ''ENDLOOP''
                5  ''CHAIN''
                8  ''ENDCHAIN''
                5  ''VALUE''
                  END
                END
```

```
29081 8X  05-01-78   14.773    COMPOOL COMPILATION OF 05CMPL          JOCIT VERSION 042275            PAGE     1

  ALTER NO      ....5....1....5....2....5....3....5....4....5....5....5....6....6....5....7....5....8          ANZC

     1          ''I JAVSTEXT J5POOL PRESET 'I
     2           START $                                                          J4CMPL 2
     3               ''      JAVS-5  --  MODULE INSTRUMENTATION COMPONENT      ''   0729RU 6
     4               ''      ''                                                   TEMP   1
     5                  DEFINE TRUE '' 1 '' $                                     BDEFINS2
     6                  DEFINE FALSE '' 0 '' $                                    BDEFINS3
     7                  DEFINE INTG '' I 24 S '' $                                DEFINS 2
     8                  DEFINE HLL '' H 4 '' $                                    DEFINS 3
     9                  DEFINE DINTG '' I 48 S '' $                               DDEFINS2
    10                  DEFINE DHLL '' H 8 '' $                                   DDEFINS3
    11               ''    ..........  LOCAL COMMON BLOCKS ..........   ''        J4CMPL 6
    12               ''                                 ''                        BLKSTO 2
    13               ''      BLOCK STORAGE COMMON       ''                        BLKSTO 3
    14               ''                                 ''                        BLKSTO 4
    15           COMMON BLKSTO $                                                  BLKSTO 5
    16             BEGIN                                                          BLKSTO 6
    17               ARRAY IX 100 INTG $                                          BLKSTO 7
    18                 ARRAY LX 100 HLL  $                                        BLKSTO 8
    19                 OVERLAY IX = LX $                                          BLKSTO 9
    20             END                                                            BLKSTO10
    21               ''                                          ''               GLOBAL 2
    22               ''      GLOBAL SYMBOL DEFINITION COMMON     ''               GLOBAL 3
    23               ''                                          ''               GLOBAL 4
    24           COMMON GLOBAL $                                                  GLOBAL 5
    25             BEGIN                                                          GLOBAL 6
    26                 ITEM IGLOBLK HLL $                                         GLOBAL 7
    27                 ITEM IGLOUND HLL $                                         GLOBAL 8
    28                 ITEM LBLANK HLL $                                          GLOBAL 9
    29                 ITEM IBLANK INTG $                                         GLOBAL10
    30                 OVERLAY LBLANK = IBLANK $                                  GLOBAL11
    31             END                                                            GLOBAL12
    32               ''                                        ''                 MTHSTO 2
    33               ''      STATEMENT LIST STORAGE COMMON     ''                 MTHSTO 3
    34               ''                                        ''                 MTHSTO 4
    35             COMMON MTHSTO $                                                MTHSTO 5
    36                 BEGIN                                                      MTHSTO 6
    37                   ARRAY LLIST 2 250 HLL $                                  MTHSTO 7
    38                   ARRAY ILIST 2 250 INTG $                                 MTHSTO 8
    39                   OVERLAY LLIST = ILIST $                                  MTHSTO 9
    40                 END                                                        MTHSTO10
    41                 ''                                 ''                      TXTSTO 2
    42                 ''    TEXT STORAGE COMMON          ''                      TXTSTO 3
    43                 ''                                 ''                      TXTSTO 4
    44                 COMMON TXTSTO $                                            TXTSTO 5
    45                 BEGIN                                                      TXTSTO 6
    46                   ARRAY LTEXT 250 HLL $                                    TXTSTO 7
    47                   ARRAY ITEXT 250 INTG $                                   TXTSTO 8
    48                   OVERLAY LTEXT = ITEXT $                                  TXTSTO 9
    49                 END                                                        TXTSTO10
    50                 COMMON BUFFER $                                            J4CMPL13
```

```
29087 8X  05-01-78   18.773     COMPOOL COMPILATION OF Q5CMPL          JOCIT VERSION 042275                 PAGE    2

   ALTER NO      ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                         ANZC

   51                  BEGIN                                                                      J4CMPL14
   52                    ARRAY LBUFF 100 HLL $                                                    J4CMPL15
   53                    ARRAY IBUFF 100 INTG $                                                   J4CMPL16
   54                    OVERLAY LBUFF = IBUFF $                                                  J4CMPL17
   55                  END                                                                        J4CMPL18
   56                  COMMON TABNOS $                                                            J4CMPL19
   57                  BEGIN                                                                      J4CMPL20
   58                    ITEM DDPNUM INTG $                                                       J4CMPL21
   59                    ITEM DSNUM  INTG $                                                       J4CMPL22
   60                    ITEM PRBNUM INTG $                                                       J4CMPL23
   61                    ITEM MDBNUM INTG $                                                       J4CMPL24
   62                    ITEM SBNUM  INTG $                                                       J4CMPL25
   63                    ITEM SDBNUM INTG $                                                       J4CMPL26
   64                    ITEM SLTNUM INTG $                                                       J4CMPL27
   65                    ITEM STBNUM INTG $                                                       J4CMPL28
   66                  END                                                                        J4CMPL29
   67                  COMMON DIRCOM $                                                            0604JB 1
   68                  BEGIN                                                                      0604JB 2
   69                  ''COMMON FOR DIRECTIVES GLOBAL VARIABLES''                                 0604JB 3
   70                    ARRAY STACK 20 INTG $  ''POINTERS TO START OF SYMBOL IN SB''             0604JB 4
   71                    ITEM COMMA HLL P 4H(,   ) $                                              0604JB 5
   72                    ITEM DECLARED B $                                                        0604JB 6
   73                    ITEM FLAGVAR H 8 P 8H(FLEG:    )$                                        C022JUL1
   74                    ITEM INEXT INTG $                                                        0604JB 8
   75                  ITEM MAXTXT INTG P 148 $                                                   0806JB 1
   76                    ITEM STACK'PTR INTG $                                                    0604JB12
   77                    ITEM TABL'PRESENT B R 0$                                                 0730JB 1
   78                    ITEM TVBNUM INTG $                                                       0604JB15
   79                    ITEM TVINUM INTG $                                                       0604JB16
   80                    ITEM TXTBUF H 148 $                                                      0806JB 2
   81                  END                                                                        0604JB18
   82              COMMON ASSERT $
   83              BEGIN
   84              ''COMMON FOR ASSERTIONS COMMAND STACK.''
   85              ''      JOHN L. RAMEY -- 2/27/78''
   86                DEFINE MAXCSTR ''10'' $
   87                ITEM DCLASSCNT B $ ''INDICATES IF ASSCNT HAS BEEN DECLARED YET''
   88                ITEM CSTRPTR INTG $ ''POINTS TO CURRENT TOP OF STACK''
   89                TABLE CMDSTK R MAXCSTR $ ''ASSERTION COMMAND STACK''
   90                BEGIN
   91                  ITEM VARNAME H  24 $  ''INDEX NAME''
   92                  ITEM LENNAME INTG $  ''LENGTH OF INDEX NAME''
   93                  ITEM NEXTVAL H 48 $  ''ARITH EXPR. FOR NEXT INDEX VALUE''
   94                  ITEM LENNEXT INTG $  ''LENGTH OF NEXTVAL''
   95                  ITEM EXIT    H 48 $  ''EXIT CONDITION''
   96                  ITEM LENEXIT INTG $  ''LENGTH OF EXIT''
   97                  ITEM LABEL   H  6 $  ''LABEL AT TOP OF LOOP''
   98                  ITEM LENLABL INTG $  ''LENGTH OF LABEL''
   99                  ITEM ELABEL  H  6 $  ''LABEL AT EXIT FROM LOOP''
  100                  ITEM LENELBL INTG $  ''LENGTH OF ELABEL''
```

```
2906T 0I 05-01-78   14.773   COMPOOL COMPILATION OF 05CMPL          JOCIT VERSION 042275                PAGE    3

  ALTER NO         ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8              AN2C

  101                ITEM MINCNT  H  24 S  I'MIN OF RECORD CNT RANGE''
  102                ITEM LENMIN  INTG S  'ILENGTH OF MINCNT''
  103                ITEM MAXCNT  H  24 S  I'MAX OF RECORD CNT RANGE''
  104                ITEM LENMAX  INTG S ''LENGTH OF MAXCNT''
  105               END
  106            END
  107                COMMON J4COM S                                                      J4CMPL30
  108                BEGIN                                                               J4CMPL31
  109            ARRAY ASTRTX 10 DHLL S  ''PROBI START TEST TEXTS''
  110            ARRAY STRIES 10 DHLL S  ''PROBI START TEST NAMES''
  111            ARRAY STRTFG 10 HLL S  ''PROBI START TEST TFLAG''
  112            ARRAY ASTRMD 10 DHLL S   'IPROBI START TEST MODULE ''
  113            ARRAY ASTRSM 10 INTG S   'I PROBI START TEST SMT, NO. ''
  114            ITEM NPI INTG S            'I NOT OF START TEST PROBI CALLS ''
  115                 ARRAY FBSTACK 100 INTG S  I' FALSE BRANCH STACK FOR IFTS ''        J4CMPL32
  116                 ARRAY FBPATH 100 INTG S  'I FALSE BRANCH DD-PATH NUMBERS FOR      J4CMPL33
  117                                          IF STATEMENTS ''                         J4CMPL34
  118                 ARRAY FDDPS 100 INTG S  I' DD-PATH NUMBERS FOR FALSE BRANCH       J4CMPL35
  119                                          IN IFEITH-ORIF-END STATEMENTS ''         J4CMPL36
  120                 ARRAY IFREST 100 INTG S  'I STACK OF FALSE BRANCHES FOR IFEITH    J4CMPL37
  121                                          ORIF-END STATEMENTS ''                   J4CMPL38
  122                 ITEM BEGST INTG S  'ISTARTING WORD-PAIR OF STATEMENT IN SB''     J4CMPL39
  123                 ITEM BLANKS H 150 P 150H(                                         J4CMPL40
  124                                                                                   J4CMPL41
  125                                                ) S                                J4CMPL42
  126                 ITEM BLNK HLL P 4H(     ) S    '' HOLERITH BLANK ''               J4CMPL43
  127                 ITEM BLOCK INTG S    I'INDEX OF CURRENT PROBE BLOCK BEING ''      J4CMPL44
  128                                      I'STORED IN THE PROBE TABLE''               J4CMPL45
  129                 ITEM BUFOUT H 150 S   I' TEXT EXTRACTION BUFFER ''               J4CMPL46
  130                 ITEM CFOR INTG S  ''SDD NUMBER OF CONTROLLING FOR OF              J4CMPL47
  131                                      PARALLEL FOR''                              J4CMPL48
  132              ITEM ENDMOD  DHLL S   I'MODULE WHICH ENDS TESTCASE''                 J4CMPL50
  133              ITEM ENDSTMT HLL  S   I'STATEMENT WHICH ENDS TESTCASE''              J4CMPL51
  134                ITEM IENDST INTG  S          ''SAME AS ENDSTMT''                   J4CMPL52
  135                 OVERLAY IENDST = ENDSTMT S
  136              ITEM ENDTXT  DHLL S   I'JAVSTEXT WHICH ENDS TESTCASE''               J4CMPL54
  137                 ITEM DEBUG B S  ''DEBUGGING OUTPUT FLAG''                         J4CMPL55
  138                 ITEM FBLOCK INTG S  I'INDEX OF FIRST PROBE BLOCK FOR PROBED I'   J4CMPL56
  139                                      I'STATEMENT''                               J4CMPL57
  140                 ITEM FIRSTX INTG S  I' FIRST EXECUTABLE STATEMENT ''             J4CMPL58
  141                 ''TEMPLATE FOR FIRST PROBE ''                                     J4CMPL59
  142                 ITEM FRSTPRB H 52 P 52H(PROBM     ( 8H(MODULNAM) ( 8H(TEXTNAME) ,J4CMPL60
  143         IIII ) S    ) S                                                           J4CMPL61
  144                 ITEM HDUMMY HLL S  'I DUMMY HOLLERITH PARAMETER ''                J4CMPL62
  145                 ITEM HTEMP HLL S  '' TEMPORARY HOLLERITH VARIABLE ''              J4CMPL63
  146                 ITEM IDUMMY INTG S  I' DUMMY INTEGER PARAMETER ''                 J4CMPL64
  147                 ITEM ITYPE INTG S   I'INTEGER STATEMENT TYPE''                    J4CMPL65
  148                 ITEM KBLOCK INTG S  I'INDEX OF PROBE STATEMENT BLOCK BEGIN''      J4CMPL67
  149                                     I'STORED ''                                   J4CMPL68
  150                 ITEM LASTDDP INTG S   I' LAST DD-PATH SEARCHED ''                 J4CMPL69
```

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ALTER NO       ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                          ANZ1

   1          ''7 JAVSTEXT STEP3 COMPUTE (U5POOL) ''
   2           START
   3
   4                PROC STEP3 (MODULE, LNUM, UTABLE = IANY) $                                    STEP3  3
   5                ''      JAVS-5  --  MODULE INSTRUMENTATION COMPONENT        ''                0729RU 6
   6                ''      ''                                                                    TEMP   1
   7                '' JAVS TEST CASE INSTRUMENTATION STEP ''                                     STEP3  4
   8                ''REVISION OF APRIL 15, 1975''                                                STEP3  5
   9                  DEFINE INTG '' I 24 S '' $                                                  DEFINS 2
  10                  DEFINE HLL '' H 4 '' $                                                      DEFINS 3
  11                  DEFINE DINTG '' I 48 S '' $                                                 DDEFINS2
  12                  DEFINE DHLL '' H 8 '' $                                                     DDEFINS3
  13                  DEFINE TRUE '' 1 '' $                                                       BDEFINS2
  14                  DEFINE FALSE '' 0 '' $                                                      BDEFINS3
  15                  DEFINE NBYTWD '' 4 '' $                                                     MACHDEP2
  16                ARRAY LTABLE 2 25 DHLL $                                                      STEP3 10
  17                ITEM IANY INTG $                                                              STEP3 12
  18                ITEM CNUM INTG $                                                              STEP3 13
  19                ITEM MODULE INTG $                                                            STEP3 14
  20                ITEM LTES DHLL $
  21                ITEM MLFLG HLL $
  22                BEGIN                                                                         STEP3 15
  23                  IF MCALLED5 EQ 0 $
  24                    BEGIN                                                                     STEP3 18
  25                      MCALLED5 = 1 $
  26                      VPRBE = 8H(PROBE    ) $                                                 STEP3 20
  27                      VPRBI = 8H(PROBI    ) $                                                 STEP3 21
  28                      VPRBM = 8H(PROBM    ) $                                                 STEP3 22
  29                      PMODE = PATHS $                                                         STEP3 23
  30                      DEBUG = FALSE $                                                         STEP3 25
  31                      ISTRST = -1$                                                            STEP3 27
  32                      IENDST = -1$                                                            STEP3 28
  33                    NPI = 0 $
  34                    END                                                                       STEP3 29
  35                  IANY = 1 $                                                                  STEP3 30
  36                  IFEITH LTABLE($0, 0$) EQ 8H(INSTRUME) $                                     STEP3 31
  37                    BEGIN                                                                     STEP3 32
  38                      IFEITH LNUM EQ 1 $                                                      STEP3 33
  39                        BEGIN                                                                 STEP3 34
  40                  IF MODULE LQ 0 $                                                            STEP3 35
  41                    BEGIN                                                                     STEP3 36
  42                      ERROR (18H(BAD MODULE NUMBER?) ) $                                      STEP3 37
  43                      IANY = 0 $                                                              STEP3 38
  44                      RETURN $                                                                STEP3 39
  45                    END                                                                       STEP3 40
  46                          DDPNUM = NUMDDP (IDUMMY) $                                          STEP3 41
  47                          MDBNUM = NUMMDB (IDUMMY) $                                          STEP3 42
  48                          SBNUM = NUMSB (IDUMMY) $                                            STEP3 43
  49                          SDBNUM = NUMSDB (IDUMMY) $                                          STEP3 44
  50                          SLTNUM = NUMSLT (IDUMMY) $                                          STEP3 45
```

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29061 52  05-01-78    11.801      JOVIAL COMPILATION OF SORCE5           UOCIT VERSION 042275                  PAGE      2

    ALTER NO        ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                  ANZ1

    51                        STBNUM = NUMSTB (IDUMMY) $                                                    STEP3 46
    52                        PRBNUM = NUMPRB ( IDUMMY ) $                                                  STEP3 47
    53                        UPROBE (MODULE) $                                                             STEP3 48
    54                        MCALLED5 = 0 $
    55                      END                                                                             STEP3 50
    56                  ORIF LTABLE ($ 0 , 1 $) EQ 8H(PROBE    ) $                                          STEP3 51
    57                    BEGIN                                                                             STEP3 52
    58                      IFEITH LTABLE($0,2$) EQ 8H(DDPATH  ) $                                          STEP3 53
    59                        VPRBE = LTABLE($5,8$) $                                                       STEP3 54
    60                      ORIF   LTABLE($0,2$) EQ 8H(MODULE  ) $                                          STEP3 55
    61                        VPRBM = LTABLE($5,8$) $                                                       STEP3 56
    62                      ORIF   LTABLE($0,2$) EQ 8H(TEST    ) $                                          STEP3 57
    63                        VPRBI = LTABLE($5,8$) $                                                       STEP3 58
    64                      ORIF 1 $                                                                        STEP3 59
    65                        IANY = 0 $                                                                    STEP3 60
    66                      END                                                                             STEP3 61
    67                    END                                                                               STEP3 62
    68                  ORIF LTABLE($0,1$) EQ 8H(MODE    ) $                                                STEP3 63
    69                    BEGIN                                                                             STEP3 64
    70                      IFEITH LTABLE($1,1$) EQ 8H(FULL    ) $                                          STEP3 65
    71                        PMODE = FULL $                                                                STEP3 66
    72                      ORIF LTABLE ($1,1$) EQ 8H(INVOCATI) $                                           STEP3 67
    73                        PMODE = INVOKE $                                                              STEP3 68
    74                      ORIF LTABLE($1,1$) EQ 8H(DIRECTIV) $                                            STEP3 69
    75                        PMODE = DIRTS $                                                               STEP3 70
    76                      ORIF LTABLE($1,1$) EQ 8H(DDPATHS ) $                                            STEP3 71
    77                        PMODE = PATHS $                                                               STEP3 72
    78                      ORIF LTABLE($1,1$) EQ 8H(DD-PATHS) $                                            STEP3 73
    79                        PMODE = PATHS $                                                               STEP3 74
    80                      ORIF 1 $                                                                        STEP3 75
    81                        BEGIN                                                                         STEP3 76
    82                          IANY = 0 $                                                                  STEP3 77
    83                          BYTE($0,128$) (LINE) = BYTE($0,128$) (BLANKS) $                             STEP3 78
    84                          BYTE($0, 32$) (LINE) = 32H(0INSTRUMENTATION MODE BEGINNISTEP3 79
    85          NG ) $                                                                                      STEP3 80
    86                          BYTE($32,8$) (LINE) = BYTE($0,8$) (LTABLE($1,1$)) $                         STEP3 81
    87                          BYTE($40,21$) (LINE) = 21H( IS NOT A VALID MODE.) $                         STEP3 82
    88                          OUTBUF (LENLIN, LINE) $                                                     STEP3 83
    89                        END                                                                           STEP3 84
    90                      END                                                                             STEP3 85
    91                    END                                                                               STEP3 86
    92                  ORIF LTABLE($0,1$) EQ 8H(STARTTES) $                                                STEP3 87
    93                    BEGIN                                                                             STEP3 88
    94                     NPI = NPI+1 $
    95                      STRMOD = LTABLE ($5,8$) $                                                       STEP3 89
    96                      STRTXT = LTABLE($0,8$) $                                                        STEP3 90
    97          ISTRST = 0 $
    98                      BYTE($0,NBYTWD$) (STRSTMT) = BYTE($NBYTWD,NBYTWD$)                              STEP3 91
    99                                                            (LTABLE($0,3$)) $                         STEP3 92
    100                   IFEITH BYTE($0,8$)(LTABLE($0,4$)) EQ 8H(        ) $
```

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ALTER NO     ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8            ANZ1
                   LTES = 8H(CASE     ) $
                 ORIF 1 $
                   LTES = LTABLE($0,4$) $
                 END
             BYTE($0,NBYTHDS)(MLFLG) = BYTE($NBYTHD,NBYTHDS)(LTABLE($0,5$)) $
                IF NPI LQ 10 $
                BEGIN
                  ASTRTX($NPI-1$) = SRRTXT $
                  ASTRMD($NPI-1$) = SRRMOD $
                  ASTRSM($NPI-1$) = ISTRST $
                 STRTES($NPI-1$) = LTES $
                 STRTFG($NPI-1$) = MLFLG $
                 END
                 END                                                              STEP3 93
               ORIF LTABLE($0,1$) EQ 8H(STOPTEST) $                               STEP3 94
                 BEGIN                                                            STEP3 95
                   ENDMOD  = LTABLE($1,1$) $                                      STEP3 96
        IENDST = 0 $
                   ENDTXT  = LTABLE($0,8$) $                                      STEP3 97
                   BYTE($0,NBYTHDS) (ENDSTMT) = BYTE($NBYTHD,NBYTHDS)             STEP3 98
                                                (LTABLE($0,8$)) $                 STEP3 99
                 END                                                              STEP3100
               ORIF LTABLE ($0,1$) EQ 8H(DEBUG    ) $                             STEP3110
                 DEBUG = TRUE $                                                   STEP3111
               ORIF 1 $                                                           STEP3112
                 IANY = 0 $                                                       STEP3113
               END                                                                STEP3114
               END                                                                STEP3115
               ORIF 1 $                                                           STEP3116
                 IANY = 0 $                                                       STEP3117
               END                                                                STEP3118
             END                                                                  STEP3119

             PROC ADDTXT (TEXT'STRING, CHARS, LENGTH = NEW'LENGTH) $              ADDTXT 3
             ''     JAVS-5  --  MODULE INSTRUMENTATION COMPONENT       Y''        0729RU 6
             ''          ''                                                       TEMP.  1
             ''ADDS TEXT TO THE CHARACTER STRING TXTBUF''                         ADDTXT 4
            DEFINE LEN'IN ''148'' $                                               0806JB 6
            ITEM TEXT'STRING H LEN'IN$                                            0725JB 1
             ITEM CHARS INTO $                                                    ADDTXT 8
             ITEM LENGTH INTO $                                                   ADDTXT 9
             ITEM NEW'LENGTH INTO $                                               ADDTXT10
             BEGIN                                                                ADDTXT11
            ''ASSUME THAT THE STRING IN TEXT'STRING IS RIGHT JUSTIFIED''          0709CG18
            ''MOVE CHARACTERS FROM INPUT STRING TO TEXT BUFFER ''                 0709CG19
               IFEITH (LENGTH+CHARS) LQ MAXTXT $                                  0806JB 7
               BEGIN                                                              0806JB 8
            BYTE($LENGTH+1,CHARS$) (TXTBUF) = BYTE($LENIN-CHARS,CHARS$)           0709CG20
            (TEXT'STRING)$                                                        0709CG21
            NEW'LENGTH = LENGTH+CHARS$                                            0709CG22
```

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29061 02  05-01-78   14.801      JOVIAL COMPILATION OF SORCES            UOCIT VERSION 042275                 PAGE      4
   ALTER NO        ....$...1....5....2....$....3....$....4....$....5....$....6....$....7....$....8               ANZ1
     151                 END                                                                     0806JB 9
     152                 ORIF 1 $                                                                0806JB10
     153                   FATAL ( 31H(STRING LONGER THAN TEXT BUFFER?) ) $                      0806JB11
     154                 END                                                                     0806JB12
     155               END ''ADDTXT''                                                            ADDTXT12
     156
     157               PROC BLDPRB (MODULE, DDPATH) $                                            BLDPRB 3
     158               ''      JAVS-5  --  MODULE INSTRUMENTATION COMPONENT        ''            0729RU 6
     159               ''      ''                                                                TEMP   1
     160               '' BUILDS A PROBE INVOCATION IN LTEXT''                                   BLDPRB 4
     161               ITEM DDPATH INTG $                                                        BLDPRB 7
     162               ITEM HDDP HLL $                                                           BLDPRB 8
     163               ITEM MODULE INTG $                                                        BLDPRB 9
     164               BEGIN                                                                     BLDPRB10
     165                 BYTE ($0,8$) (PRBUFR) = BYTE($0,8$) (VRRBE) $                           BLDPRB11
     166                 BYTE($13,8$) (PRBUFR) = BYTE($0,8$) (MODNAM) $                          BLDPRB12
     167                 BYTE($27,8$) (PRBUFR) = BYTE($0,8$) (TNTNAM) $                          BLDPRB13
     168                 HDDP = ITSHOL ( DDPATH ) $                                              BLDPRB14
     169                 BYTE($38,4$) (PRBUFR) = BYTE($0,4$) (HDDP) $                            BLDPRB15
     170                 FOR I = 0, 1, LENPRB-1 $                                                BLDPRB16
     171                 FOR J = 0, NBYTWD $                                                     BLDPRB17
     172                   BYTE($0,NBYTWDS) ( LTEXT($ I $) ) = BYTE($J,NBYTWDS)                  BLDPRB18
     173                   (PRBUFR) $                                                            BLDPRB19
     174               END                                                                       BLDPRB20
     175
     176               PROC BLDTXT (MODULE, STRNG, INDENT = LENTXT) $                            BLDTXT 3
     177               ''      JAVS-5  --  MODULE INSTRUMENTATION COMPONENT        ''            0729RU 6
     178               ''      ''                                                                TEMP   1
     179               DEFINE LENSTR '' 150 '' $                                                 BLDTXT 6
     180               ITEM FIRST INTG $    '' FIRST NON-BLANK CHARACTER IN STRNG ''            BLDTXT 7
     181               ITEM IDUMMY INTG $                                                        BLDTXT 8
     182               ITEM JTH INTG $                                                           BLDTXT 9
     183               ITEM RTH INTG $                                                           BLDTXT10
     184               ITEM MODULE INTG $                                                        BLDTXT11
     185               ITEM LASTBYT INTG $    '' NUMBER OF CHARACTERS IN LAST BYTE OF            BLDTXT12
     186                                          STRNG ''                                       BLDTXT13
     187               ITEM NCHARS INTG $                                                        BLDTXT14
     188               ITEM NWORDS INTG $    '' NUMBER OF 4 CHARACTER WORDS IN STRNG ''          BLDTXT15
     189               ITEM STRNG H LENSTR $                                                     BLDTXT16
     190               ITEM TEMP1 INTG $                                                         BLDTXT17
     191               ITEM INDENT INTG $                                                        BLDTXT18
     192               ITEM LENTXT INTG $                                                        BLDTXT19
     193               BEGIN      '' BLDTXT ''                                                   BLDTXT20
     194                 FOR I = 0, 1, 17 $    '' CLEAR BUFFER ''                                BLDTXT21
     195                   LTEXT($ I $) = BLNK $                                                 BLDTXT22
     196                 FOR I = 0, 1, LENSTR-1 $    '' SCAN FOR FIRST NON-BLANK CHAR ''         BLDTXT23
     197                   BEGIN                                                                 BLDTXT24
     198                     IF BYTE($ I, 1$) (STRNG) NQ BYTE($0,1$) ( BLNK ) $                  BLDTXT25
     199                       BEGIN                                                             BLDTXT26
     200                         FIRST = I $                                                     BLDTXT27
```

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ALTER NO      ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8              ANZ1

                        GOTO MOVE $                                             BLDTXT28
                    END                                                         BLDTXT29
                END                                                             BLDTXT30
              RETURN $    '' BLANK STRING ''                                    BLDTXT31
         MOVE?                                                                  BLDTXT32
              NCHARS = LENSTR - FIRST $                                         BLDTXT33
              ''FIND INTGRAL NUMBER OF WORDS TO MOVE''                          BLDTXT34
              REMQUO (NCHARS, NBYTWD = NWORDS, LASTBYT) $                       BLDTXT35
              LENTXT = NWORDS * 1 $                                             BLDTXT36
              KTH = 0 $                                                         BLDTXT37
              JTH = FIRST $                                                     BLDTXT38
              FOR I = 1, 1, NWORDS $                                            BLDTXT39
                BEGIN                                                           BLDTXT40
                  BYTE($0,NBYTWDS) (LTEXT($ KTH $)) =                           BLDTXT41
                  BYTE($JTH,NBYTWDS) (STRNG) $                                  BLDTXT42
                  JTH = JTH + NBYTWD $                                          BLDTXT43
                  KTH = KTH + 1 $                                               BLDTXT44
                END                                                             BLDTXT45
              IF LASTBYT GR 0 $                                                 BLDTXT46
                BEGIN                                                           BLDTXT47
                  BYTE($0,LASTBYTS) (LTEXT($ KTH $)) =                          BLDTXT48
                  BYTE($JTH,LASTBYTS) (STRNG) $                                 BLDTXT49
                  LENTXT = LENTXT + 1 $                                         BLDTXT50
                END                                                             BLDTXT51
            END    '' BLDTXT ''                                                 BLDTXT52

            PROC CASE2 (MODULE, STMT) $                                         CASE2  3
            ''       JAVS-5  --  MODULE INSTRUMENTATION COMPONENT        ''     0729RU 6
            ''       ''                                                         TEMP   1
            '' FINDS THE FIRST ORIF IN AN IFEITH-ORIF-END NEST BY ''            CASE2  4
            '' WALKING THE CHAIN OF POINTERS IN THE SDB UNTIL THE ''            CASE2  5
            '' IFEITH STATEMENT IS ENCOUNTERED AND THEN RETURNING ''            CASE2  6
            '' THE NEXT POINTER ''                                              CASE2  7
            DEFINE IFEIV ''4H(IFEI)'' $                                         CASE2 10
            DEFINE ORIFV ''4H(ORIF)'' $                                         CASE2 11
            DEFINE ENDV ''4H(END )'' $                                          CASE2 12
            ITEM CASE2 INTG $         ''1ST ORIF STATEMENT NUMBER''             CASE2 13
            ITEM MODULE INTG $        ''MODULE NUMBER''                         CASE2 14
            ITEM II INTG $            ''CURRENT STATEMENT IN CHAIN''            CASE2 15
            ITEM PTR INTG $           ''NEXT STATEMENT IN CHAIN''               CASE2 16
            ITEM STMT INTG $          ''CURRENT STATEMENT NUMBER''              CASE2 17
            ITEM TYPE HLL $           ''CURRENT CHAIN STATEMENT TYPE''          CASE2 18
            BEGIN                                                               CASE2 19
              CASE2 = 0 $                                                       CASE2 20
              PTR = STMT $                                                      CASE2 21
         LOOP?    II = PTR $      '' SEARCH FOR IFEITH STATEMENT ''             CASE2 22
              PTR = IGTWRD(MODULE, SEGNUM, II, 7) $                             CASE2 23
              IF PTR LQ 0 OR PTR GR NSTMTS $                                    CASE2 24
                BEGIN                                                           CASE2 25
                  ERROR (21H(POINTER OUT OF RANGE.)) $                          CASE2 26
```

```
   ALTER NO      0....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8          ANZ1

                          RETURN $                                                         CASE2 27
                        END                                                                CASE2 28
                     HTEMP = IQTLIT(MODULE, SDBNUM, PTR, 5) $                              CASE2 29
                     BYTE($0,NBYTWDS) (TYPE) = BYTE($0,NBYTWDS) (HTEMP) $                  CASE2 30
                     IF TYPE EQ ORIFV OR TYPE EQ ENDV $   GOTO LOOP $                      CASE2 31
                   IF TYPE EQ IFEIV $                                                      CASE2 32
                     BEGIN                                                                 CASE2 33
                       II = PTR $                                                          CASE2 34
                       PTR = IQTWRD(MODULE, SDBNUM, II, 7) $                               CASE2 35
                       HTEMP = IQTLIT(MODULE, SDBNUM, PTR, 5) $                            CASE2 36
                       BYTE($0,NBYTWDS) (TYPE) = BYTE($0,NBYTWDS) (HTEMP) $                CASE2 37
                       IF TYPE EQ ORIFV $                                                  CASE2 38
                         BEGIN                                                             CASE2 39
                           CASE2 = PTR $                                                   CASE2 40
                           RETURN $   '' NORMAL RETURN ''                                  CASE2 49
                         END                                                               CASE2 50
                     END                                                                   CASE2 51
                           BYTE($0,128$) (LINE) = BYTE($0,128$) (BLANKS) $                 CASE2 52
                           BYTE($0, 16$) (LINE) =  16H(POINTER IN SDB ) $                  CASE2 53
                   HTEMP = ITSHOL ( II) $                                                  CASE2 54
                   BYTE($16,4$) (LINE) =  HTEMP $                                          CASE2 55
                   BYTE($21,33$) (LINE) = 33H(POINTS TO INVALID STATEMENT TYPE ) $         CASE2 56
                   BYTE($35,4$) (LINE) = BYTE($0,4$) ( TYPE) $                             CASE2 57
                   OUTBUF ( LENLIN, LINE ) $                                               CASE2 58
                   ERROR ( 32H(INVALID STATEMENT TYPE IN CHAIN.) ) $                       CASE2 59
                 END                                                                       CASE2 60

                 PROC CONCAT ( LFTSTR, RTSTR ) $                                           CONCAT 3
                 ''      JAVS-5  --  MODULE INSTRUMENTATION COMPONENT      ''              0729RU 6
                 ''      ''                                                                TEMP   1
                 '' CONCATENATES RTSTR TO LFTSTR WITH 1 INTERVENING BLANK                  CONCAT 4
                    AND RETURNS THE RIGHTMOST LENSTR CHARACTERS ''                         CONCAT 5
                 DEFINE LENSTR '' 150 '' $                                                 CONCAT 8
                 ITEM CONCAT H LENSTR $                                                    CONCAT 9
                 ITEM RTSTR H LENSTR $  '' RIGHT SUBSTRING ''                              CONCAT10
                 ITEM LFTSTR H LENSTR $   '' LEFT SUBSTRING ''                             CONCAT11
                 ITEM RTBUFR H LENSTR $ '' RIGHT SUBSTRING BUFFER ''                       CONCAT12
                 ITEM LFTBUFR H LENSTR $  '' LEFT SUBSTRING BUFFER ''                      CONCAT13
                 ITEM II INTG $  '' FIRST NON-BLANK CHARACTER FROM LEFT                    CONCAT14
                                    IN RIGHT SUBSTRING ''                                  CONCAT15
                 ITEM  NCHARS INTG $  ''NUMBER OF CHARACTERS TO MOVE FROM RTSTR''          CONCAT16
                 BEGIN                                                                     CONCAT17
                   RTBUFR = RTSTR $                                                        CONCAT18
                   LFTBUFR = LFTSTR $                                                      CONCAT19
                   CONCAT = BLNK $                                                         CONCAT20
                   II = 0 $                                                                CONCAT21
            LOOK.  ''FOR FIRST NON-BLANK CHARACTER FROM LEFT IN RIGHT SUBSTRING''          CONCAT22
                   '' ASSERTION.  0<=II<=LENSTR  ''                                        CONCAT23
                     IF  BYTE($II,1$) (RTBUFR) NQ BYTE($0,1$) (BLNK)  $                    CONCAT24
                       GOTO FOUND $                                                        CONCAT25
```

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ALTER NO   ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                  ANZ1

                   II = II + 1 $                                                       CONCAT26
                 IF II LS LENSTR $ GOTO LOOK $                                        CONCAT27
            FOUND.                                                                     CONCAT28
                 IFEITH II GR 0 AND II LS LENSTR $                                    CONCAT29
                   BEGIN                                                               CONCAT30
                     NCHARS = LENSTR - II $                                            CONCAT31
                     BYTE($II,NCHARS$) (CONCAT) = BYTE($II,NCHARS$) (RTBUFR) $         CONCAT32
                     BYTE($0,II-1$) (CONCAT) = BYTE($NCHARS+1,II-1$) (LFTBUFR) $       CONCAT33
                   END                                                                 CONCAT34
                 ORIF II GQ LENSTR $                                                   CONCAT35
                   CONCAT = LFTBUFR $                                                  CONCAT36
                 ORIF 1 $                                                              CONCAT37
                   CONCAT = RTBUFR $                                                   CONCAT38
                 END                                                                   CONCAT39
               END ''CONCAT''                                                          CONCAT40

               PROC EXTSB (FIRST, LAST, LSTART = LENTXT) $                             EXTSB 10
               ''      JAVS-3  --  MODULE INSTRUMENTATION COMPONENT        ''          0729RU 6
               ''      ''                                                              TEMP  1
               ''EXTRACT TEXT FROM STATEMENT BLOCK TO LTEXT ARRAY''                    EXTSB 11
               DEFINE BUFR'LEN '' 72'' $                                               0710JB 1
               ITEM BUFFER H 72 $                                                      0722JB31
               ITEM FIRST INTG $  ''WHERE TO START IN SB''                             EXTSB 16
               ITEM LAST INTG $  ''WHERE TO END IN SB''                                EXTSB 17
               ITEM LSTART INTG $  ''WHERE TO START IN LTEXT''                         EXTSB 18
               ITEM LENTXT INTG $  ''LENGTH OF LTEXT''                                 EXTSB 19
               ITEM IFIRST INTG $  ''NEXT STARTING WORD IN SB''                        EXTSB 20
               ITEM ILSTRT INTG $  ''NEXT WORD TO PUT IN LTEXT''                       EXTSB 21
               ITEM NEXT INTG $  ''NEXT WORD TO GET FROM SB''                          EXTSB 22
               ITEM NWORDS INTG $  ''NUMBER OF WORDS GOTTEN FROM SB''                  EXTSB 23
               BEGIN  ''EXTSB''                                                        EXTSB 24
               IFIRST = FIRST $                                                        EXTSB 25
               ILSTRT = LSTART $                                                       EXTSB 26
               LENTXT = LSTART $                                                       0710JB 2
            GET.                                                                       EXTSB 28
               ''EXTRACT TEXT FROM STATEMENT BLOCK''                                   EXTSB 29
               BLDLIB (IFIRST, LAST, LLIST, 0, BUFR'LEN = NEXT, BUFOUT) $
               ''DETERMINE LENGTH OF BUFFER''                                          EXTSB 31
                 BYTE($0,72$) (BUFFER) = BYTE($0,72$) (BUFOUT) $                       0722JB32
                 BUFFER = JUSTRT ( BUFFER ) $                                          0722JB33
                 NWORDS = (LASTCH(BUFFER) / NBYTWD) + 1 $                              0722JB34
               ''MOVE TEXT TO LTEXT ARRAY''                                            EXTSB 33
               FOR I = ILSTRT, 1, NWORDS + ILSTRT $                                    EXTSB 34
                 FOR J = BUFR'LEN - (NWORDS * NBYTWD ), NBYTWD $                       0723JB 1
                 BYTE($0, NBYTWD$) (LTEXT($ I $) ) = BYTE($J,NBYTWD$) (BUFFER) $       0722JB35
               LENTXT = LENTXT + NWORDS $                                              EXTSB 37
               IF NEXT LQ LAST $                                                       EXTSB 38
               BEGIN                                                                   EXTSB 39
                 ILSTRT = NWORDS + ILSTRT $                                            EXTSB 40
                 IFIRST = NEXT $                                                       EXTSB 41
```

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ALTER NO      ....5....1....5....2....5....3....5....4....5....5....5....5....6....5....7....5....8        AN21

          GOTO GET $                                                     EXTSB 42
        END                                                              EXTSB 43
        END  ''EXTSB''                                                   EXTSB 44

        PROC EXTEND (MODULE, TEXT, NCHARS, STRT = LENTXT) $              EXTEND 3
        ''     JAVS-5  --  MODULE INSTRUMENTATION COMPONENT       ''     0729RU 6
        ''     ''                                                        TEMP   1
        ''ADDS TEXT TO THE END OF THE LTEXT ARRAY AND UPDATES LENTXT     EXTEND 4
          WHICH IS THE CURRENT LENGTH OF THE TEXT IN THE ARRAY''         EXTEND 5
        DEFINE MAXWORDS ''37'' $                                         0718JB12
        DEFINE MAXTEXT '' 72''$                                          0724JB 2
        ITEM LASTBIT INTG U  ''NUMBER OF CHARACTERS REMAINING AFTER      EXTEND10
                               NWORDS HAVE BEEN MOVED''                  EXTEND11
        ITEM LENTXT INTG S    ''LENGTH OF LTEXT ARRAY ON RETURN''        EXTEND12
        ITEM MODULE INTG S                                               EXTEND13
        ITEM NCHARS INTG S  ''LENGTH OF INPUT CHARATER STRING''          EXTEND14
        ITEM NWORDS INTG S  ''INTEGRAL  NUMBER OF WORDS TO MOVE''        0718JB14
        ITEM STRT INTG S   ''STARTING WORD IN LTEXT''                    EXTEND16
        ITEM TEXT H MAXTEXT $   ''INPUT CHARACTER STRING''               EXTEND17
        BEGIN   ''EXTEND''                                               EXTEND18
          IF NCHARS GR MAXTEXT $                                         0714JB11
          BEGIN                                                          EXTEND20
            ERROR ( 44H(INPUT STRING TOO LONG--TRUNCATED FROM HEAD.)) $  EXTEND21
            NCHARS = MAXTEXT $                                           EXTEND22
          END                                                            EXTEND23
          ''CALCULATE INTEGRAL NUMBER OF WORDS TO MOVE AND REMAINING     EXTEND24
            CHARACTERS''                                                 EXTEND25
          REMQUO (NCHARS, NBYTWD = NWORDS, LASTBIT) $                    EXTEND26
          IF NWORDS GR 0 $                                               0721JB 1
          BEGIN                                                          0806JB13
          FOR I = STRT, 1, STRT+NWORDS-1 $                               0806JB14
          FOR J = MAXTEXT-NCHARS, NBYTWD $                               0806JB15
            BYTE($0,NBYTWDS) (LTEXT($ I $)) = BYTE($J,NBYTWDS) (TEXT) $  0806JB16
          END                                                            0806JB17
          LENTXT = STRT + NWORDS $                                       EXTEND30
          IF LASTBIT GR 0 $                                              EXTEND31
          BEGIN                                                          EXTEND32
            BYTE($0,NBYTWDS) (LTEXT($ LENTXT $) ) = BYTE($0,NBYTWDS)     0724JB 3
 (BLNK) $                                                                0724JB 4
            BYTE($0,LASTBYTS) (LTEXT($ LENTXT $)) = BYTE($MAXTEXT-LASTBIT EXTEND34
 ,LASTBYTS) (TEXT) $                                                     EXTEND35
              LENTXT = LENTXT + 1 $                                      0721JB31
          END                                                            EXTEND36
        END ''EXTEND''                                                   EXTEND37

       PROC INTVB (MODULE,SYMBOL,SYMLEN)$                                J30724 1
        ''     JAVS-5  --  MODULE INSTRUMENTATION COMPONENT       ''     0729RU 6
        ''     ''                                                        TEMP   1
        ''RETURNS THE INDEX OF SYMBOL IN THE TRACE VARIABLE BLOCK OR 0 IF INTVB  4
          THE SYMBOL IS NOT PRESENT''                                    INTVB  5
```

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ALTER NO     ....$....1....5....2....$....3....$....4....$....5....$....6....$....7....$....8           ANZ1

                ITEM INTVB INTO $                                                   INTVB  8
               ITEM MODULE INTOS                                                    0709CG24
               ITEM SYMLEN INTOS                                                    0709CG25
               ITEM ISYMLEN INTOS                                                   JB0724 2
               ITEM SYMBOL H 32S                                                    0709CG26
               ITEM TABSYM H 32S                                                    0709CG27
               ITEM CYMBOL H 32S                                                    CG29JUL2
               ITEM TABCYM H 32S                                                    CG29JUL3
               ITEM IBEG INTOS                                                      0709CG28
                BEGIN                                                               INTVB 10
               IBEG = 0S ''INITIALIZE STARTING POINT OF SEARCH TO START OF TABLE''0709CG29
               ISYMLEN = ((SYMLEN-1)/NBYTWD)+1S                                     JB0724 3
               IF LENTVI GR 0S                                                      0709CG30
               BEGIN                                                                0709CG31
            SEARCH'TVI?                                                             0709CG32
               IBEG = IBEG+1S                                                       0709CG33
               INTVB = ISRTAB (MODULE,TVINUM,IBEG,LENTVI/1,ISYMLEN)S                JB0724 4
               IF INTVB LQ 0S   RETURNS   ''SYMBOL NOT FOUND''                      0709CG35
               CYMBOL = SYMBOLS                                                     CG29JUL5
               GETTVB (MODULE,INTVB,SYMLEN,TABSYM)S                                 CG29JUL6
               TABCYM = TABSYMS                                                     CG29JUL7
               IF BYTE($32-SYMLEN,SYMLENS)(SYMBOL) EQ BYTE($32-SYMLEN,SYMLENS)     0728JB 3
               (TABSYM)S                                                            0728JB 4
                  RETURNS   ''INDEX OF SYMBOL IN TABLE''                            0709CG38
               IBEG = INTVBS    ''UPDATE STARTING POINT OF SEARCH''                 0709CG39
               IF IBEG LS LENTVIS                                                   0728JB 5
               GOTO SEARCH'TVIS                                                     0709CG41
               END                                                                  0709CG42
                  INTVB = 0 S                                                       0728JB 6
                END ''INTVB''                                                       INTVB 11

                PROC UPROBE ( MODULE ) $                                            JPROBE 3
                ''     JAVS-5  --  MODULE INSTRUMENTATION COMPONENT      ''         0729RU 6
                ''     ''                                                           TEMP   1
                ''REVISION OF APRIL 14, 1975''                                      JPROBE 4
                ITEM LINE H 120 $                                                   JPROBE 9
                ITEM MODULE INTG $                                                  JPROBE10
                  ITEM MTYPE HLL $
                BEGIN                                                               JPROBE11
               DECLARED = FALSES                                                    JB0724 6
               DCLASSENT = FALSE $
               CSTKPTR = -1 $ ''INITIALIZE ASSERTION STACK PTR''
                  TOP = 0 $                                                         JPROBE12
                  FBSTACK($ 0 $) = 0 $                                              JPROBE13
                  FDDES ($ 0 $) = 0 $                                               JPROBE14
                  LASTIF = 0 $                                                      JPROBE15
                  LASTDOP = 0 $                                                     JPROBE16
                  MXDOP = IGTWRD (MODULE, MDBNUM, 1, 25) $                          JPROBE17
                  MODNAM = MDBMOD ( MODULE ) $                                      JPROBE18
                  TXTNAM = MDBTXT (MODULE) $                                        JPROBE19
```

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  ALTER NO        ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                 AN21

                  BYTE($0,128$) (LINE) = BYTE($0,128$) (BLANKS) $                      JPROBE20
                  BYTE($0,61$) (LINE) = 61H(0JOVIAL AUTOMATED VERIFICATION SYSTEM JPROBE21
          *** INSTRUMENTATION ***) $                                                   JPROBE22
                  OUTBUF ( LENLIN, LINE ) $                                            JPROBE23
                  BYTE($0,128$) (LINE) = BYTE($0,128$) (BLANKS) $                      JPROBE24
                  BYTE($0,24$) (LINE) = 24H(0OPTIONS IN EFFECT . . .) $                JPROBE25
                  OUTBUF (LENLIN, LINE) $                                              JPROBE26
                  BYTE($0,128$) (LINE) = BYTE($0,128$) (BLANKS) $                      JPROBE27
                  BYTE($30,17$) (LINE) = 17H( DD-PATH PROBE * ) $                      JPROBE28
                  BYTE($57,8$) (LINE) = BYTE($0,8$) (VPRBE) $                          JPROBE29
                  OUTBUF (LENLIN, LINE) $                                              JPROBE30
                  BYTE($0,128$) (LINE) = BYTE($0,128$) (BLANKS) $                      JPROBE31
                  BYTE($30,17$) (LINE) = 17H( MODULE  PROBE * ) $                      JPROBE32
                  BYTE($57,8$) (LINE) = BYTE($0,8$) (VPRBM) $                          JPROBE33
                  OUTBUF (LENLIN, LINE) $                                              JPROBE34
                  BYTE($0,128$) (LINE) = BYTE($0,128$) (BLANKS) $                      JPROBE35
                  BYTE($30,17$) (LINE) = 17H( TEST    PROBE * ) $                      JPROBE36
                  BYTE($57,8$) (LINE) = BYTE($0,8$) (VPRBI) $                          JPROBE37
                  OUTBUF (LENLIN, LINE) $                                              JPROBE38
                  BYTE($0,128$) (LINE) = BYTE($0,128$) (BLANKS) $                      JPROBE39
                  BYTE($0,15$) (LINE) = 15H(0INSTRUMENTING ) $                         JPROBE40
                  IFEITH PMODE EQ INVOKE $                                             JPROBE41
                    BYTE($15,24$) (LINE) = 24H(ENTRY POINTS AND RETURNS) $             JPROBE42
                  ORIF PMODE EQ PATHS $                                                JPROBE43
                    BYTE($15,34$) (LINE) =34H(ENTRY POINTS, RETURNS AND DD-PATHS)$JPROBE44
                  ORIF PMODE EQ DIRTS $                                                JPROBE45
                    BYTE($15,10$) (LINE) = 10H(DIRECTIVES) $                           JPROBE46
                  ORIF PMODE EQ FULL $
                    BYTE($15,23$) (LINE) = 23H(DD-PATHS AND DIRECTIVES) $
                  END                                                                  JPROBE47
                  BYTE($49,12$) (LINE) = 12H( OF MODULE () $                           JPROBE48
                  BYTE($61,8$) (LINE) = BYTE($0,8$) (MODNAM) $                         JPROBE49
                  BYTE($69,15$) (LINE) = 15H() OF JAVSTEXT () $                        JPROBE50
                  BYTE($84,8$) (LINE) = BYTE($0,8$) (TXTNAM) $                         JPROBE51
                  BYTE($92,1$) (LINE) = 1H)) $                                         JPROBE52
                  OUTBUF (LENLIN, LINE) $                                              JPROBE53
                  NSTMTS = IGTWRD (MODULE, MDBNUM, 1, 10) $                            JPROBE54
                  FIRSTX = IGTWRD(MODULE, MDBNUM, 1, 12) $                             JPROBE55
                  IF FIRSTX LQ 0 $                                                     JPROBE56
                    BEGIN                                                              JPROBE57
                      BYTE($0,128$) (LINE) = BYTE($0,128$) (BLANKS) $                  JPROBE58
                      BYTE($0, 47$) (LINE) = 47H(0THERE ARE NO EXECUTABLE STATEMENJPROBE59
          TS IN MODULE () $                                                            JPROBE60
                      BYTE($47,8$)  (LINE) = BYTE($0,8$) (MODNAM) $                    JPROBE61
                      BYTE($55,15$) ( LINE) = 15H() OF JAVSTEXT () $                   JPROBE62
                      BYTE($70, 8$) (LINE) = BYTE($0,8$) (TXTNAM) $                    JPROBE63
                      BYTE($78, 2$) (LINE) = 2H().) $                                  JPROBE64
                      OUTBUF (LENLIN, LINE) $                                          JPROBE65
                      RETURN $                                                         JPROBE66
                    END                                                                JPROBE67
  ALTER NO     ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8      ANZ1

                 ''FIND THE LAST EXECUTABLE STATEMENT IN THE MODULE ASSUMING   ''JPROBE68
               ''  THAT IT IS NOT A DECLARATION INCLUDING AN END               ''JPROBE69
                 HTEMP = IGTLIT(MODULE, SDBNUM, NSTMTS, 5) $                     JPROBE70
                 BYTE($0,NBYTWDS) (STYPE) = BYTE($0,NBYTWDS) (HTEMP) $           JPROBE71
                 HTEMP = IGTLIT ( MODULE, MDBNUM, 1, 3 ) $
                 BYTE($0,NBYTWDS) (MTYPE) = BYTE($0,NBYTWDS) (HTEMP) $
                 IFEITH STYPE EQ ENDV $                                          JPROBE72
                   LASTX = NSTMTS $                                              JPROBE73
                 ORIF (STYPE EQ TERMV) AND (MTYPE EQ 4H(PROG)) $
                   LASTX = NSTMTS $
                 ORIF   STYPE EQ TERMV $                                         JPROBE74
                   BEGIN                                                         JPROBE75
                   FOR I = NSTMTS-1, -1, 1 $
                     BEGIN
                     HTEMP = IGTLIT ( MODULE, SDBNUM, I, 5 ) $
                     BYTE($0,NBYTWDS) (STYPE) = BYTE($0,NBYTWDS) (HTEMP) $
                     IF STYPE EQ ENDV $
                       BEGIN
                       LASTX = I $
                       GOTO FOUND $
                       END
                     END
                   ERROR ( 35H(NO EXECUTABLE STATEMENTS IN MODULE.) ) $
                   RETURN $
           FOUND.
                   END                                                           JPROBE84
                 ORIF 1 $                                                        JPROBE85
                   BEGIN                                                         JPROBE86
                     ERROR (44H(LAST STATEMENT IN MODULE IS NOT TERM OR END.))$  JPROBE87
                     RETURN $                                                    JPROBE88
                   END                                                           JPROBE89
                 END                                                             JPROBE90
                 BLOCK = 0 $                                                     JPROBE91
                 CFOB = 0 $                                                      JPROBE92
                 BYTE($0,8$) (TESTPRB) = BYTE($0,8$) (VERBI) $                   JPROBE93
               IFEITH (PMODE EQ PATHS) OR (PMODE EQ DIRTS) OR (PMODE EQ FULL) $  0604JB68
                   PRBJ3 (MODULE) $                                              JPROBE95
                 ORIF   PMODE EQ INVOKE $                                        JPROBE96
                   PRBENT ( MODULE) $                                            JPROBE97
                 ORIF 1  $              ''MODE NOT IMPLEMENTED''                 JPROBE98
                   BEGIN                                                         JPROBE99
                     BYTE($0,128$) (LINE) = BYTE($0,128$) (BLANKS) $             JPROB100
                     BYTE($0, 23$) (LINE) = 23H(0INSTRUMENTATION MODE  ) $       JPROB101
                     BYTE($23, 4$) (LINE) = BYTE($0,4$) (PMODE) $                JPROB102
                     BYTE($27,22$) (LINE) = 22H(  NOT YET IMPLEMENTED.) $        JPROB103
                     OUTBUF (LENLIN, LINE) $                                     JPROB104
                   BLOCK = 1 $                                                   JPROB105
                   END                                                           JPROB106
                 END                                                             JPROB107
                 ''STORE TOTAL NUMBER OF PROBE STATEMENT BLOCKS''                JPROB108
```

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 ALTER NO      ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                   ANZ1

                     IF BLOCK GR 0$                                                      0730JB 2
                     PUTURD (MODULE, MDBNUM, 1, 26, BLOCK-1) $                           JPROB109
                   END                                                                   JPROB110

                   PROC JUSTRT ( STRNG) $                                                JUSTRT 3
                   ''     JAVS-5  --  MODULE INSTRUMENTATION COMPONENT      ''           0729RU 6
                   ''     ''                                                             TEMP   1
                   ''RIGHT JUSTIFY A LEFT JUSTIFIED CHARACTER STRING WITH LEADING         JUSTRT 4
                     BLANKS''                                                            JUSTRT 5
                   DEFINE LENSTR '' 150 '' $                                             JUSTRT 8
                   ITEM II INTG $                                                        JUSTRT 9
                   ITEM JUSTRT H LENSTR $                                                JUSTRT10
                   ITEM STRNG H LENSTR $                                                 JUSTRT11
                   BEGIN   ''JUSTRT''                                                    JUSTRT12
                     ''CLEAR RETURN STRING''                                             JUSTRT13
                     JUSTRT = BLNK $                                                     JUSTRT14
                     ''SEARCH FOR FIRST NON-BLANK CHARACTER FROM RIGHT TO LEFT IN        JUSTRT15
                       STRING''                                                          JUSTRT16
                     II = LENSTR $                                                       JUSTRT17
             LOOP.                                                                       JUSTRT18
                       II = II - 1 $                                                     JUSTRT19
                     IF BYTE($II,1$) (STRNG) NQ BYTE($0,1$) (BLNK) $ GOTO MOVE $         JUSTRT20
                     IF II GR 0 $  GOTO LOOP $                                           JUSTRT21
                     RETURNS  ''ALL BLANKS''                                             JUSTRT22
             MOVE.   ''CHARACTERS FROM INPUT TO OUTPUT STRING''                          JUSTRT23
                     BYTE($LENSTR-II-1,II+1$) (JUSTRT) = BYTE($0,II+1$) (STRNG) $        JUSTRT24
                   END  ''JUSTRT''                                                       JUSTRT25

                   PROC LASTCH ( BUFFER ) $                                              LASTCH 3
                   ''     JAVS-5  --  MODULE INSTRUMENTATION COMPONENT      ''           0729RU 6
                   ''     ''                                                             TEMP   1
                   ''*** ORIGINAL SPECIFICATION ***''                                    0722JB11
                   ''INTEGER FUNCTION -- RETURNS THE BYTE NUMBER OF THE LAST ''          LASTCH 4
                   ''NON-BLANK CHARACTER IN THE INPUT BUFFER      ''                     LASTCH 5
                   ''*** CHANGED SPECIFICATION *** ''                                    0722JB12
                   ''RETURNS THE LENGTH OF THE INPUT STRING BY SCANNING FROM LEFT TO     0722JB13
                     RIGHT AND IGNORING PRECEDING BLANKS''                               0722JB14
                ''WARNING --- LASTCH ASSUMES THAT THE INPUT CHARACTER                    0722JB15
                             STRING IS RIGHT JUSTIFIED ''                                0722JB16
                     ITEM LASTCH INTG $                                                  LASTCH 8
                   DEFINE MXBUF ''150''$                                                 0722JB17
                   ITEM BUFFER H MXBUF$                                                  0722JB18
                    BEGIN                                                                LASTCH10
                      FOR I = 0, 1, MXBUF-1 $                                            0722JB19
                        BEGIN ''SEARCHING FOR FIRST NON-BLANK CHARACTER FROM LEFT''      0722JB10
                          IF BYTE($I,1$) (BUFFER) NQ BYTE($0,1$) (BLNK) $                LASTCH13
                            BEGIN                                                        LASTCH14
                              LASTCH = MXBUF - I $                                       0722JB11
                              RETURN $                                                   LASTCH16
                            END                                                          LASTCH17
```

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  ALTER NO       ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                  ANZ1

  601                END                                                                  LASTCH18
  602              LASTCH = 0 $                                                           LASTCH19
  603            END 'LASTCH'                                                             LASTCH20
  604
  605            PROC MAKE (MODULE, STRNG , NCHARS, INDENT = LENTXT) $                    MAKE   3
  606            ''     JAVS-5  --  MODULE INSTRUMENTATION COMPONENT      ''                0729RU 6
  607            ''     ''                                                                TEMP   1
  608            DEFINE MXSTRG ''140'' $ '' MAXIMUM LENGTH OF STRING ''                   0806JB18
  609            ITEM INDENT INTG $         '' NUMBER OF CHARACTERS TO INDENT ''          MAKE   7
  610            ITEM JJ INTG $             '' CHARACTER INDEX ''                         MAKE   8
  611            ITEM KK INTG $             '' WORD INDEX ''                              MAKE   9
  612            ITEM LASTBYT INTG $        '' NUMBER OF CHARACTERS IN LAST WORD OF       MAKE  10
  613                                          LTEXT ARRAY ''                              MAKE  11
  614            ITEM LNSTRG INTG $         '' TOTAL STRING LENGTH INCLUDING INDENT ''   MAKE  12
  615            ITEM LENTXT INTG $         '' LENGTH OF OUTPUT ARRAY LTEXT ''            MAKE  13
  616            ITEM MODULE INTG $         '' MODULE NUMBER ''                           MAKE  14
  617            ITEM NCHARS INTG $         '' NUMBER OF CHARACTERS IN INPUT STRING ''   MAKE  15
  618            ITEM NWORDS INTG $         '' NUMBER OF FOLL NBYTWD WORDS IN STRING''   MAKE  16
  619            ITEM STRNG H MXSTRG $  '' INPUT CHARACTER STRING ''                     0806JB19
  620           BEGIN                                                                     MAKE  18
  621             ''.....CAUTION--MAKE EXPECTS THE CHARACTER STRING IN STRNG             0718JB 1
  622                           TO BE RIGHT JUSTIFIED ''                                  0718JB 2
  623             ''                 .....                                         ''   0718JB 3
  624             LNSTRG = NCHARS + INDENT $                                            MAKE  19
  625             IF LNSTRG GR  MXSTRG $                                                MAKE  20
  626               BEGIN                                                               MAKE  21
  627                 ERROR (44H(INPUT STRING TOO LONG--TRUNCATED FROM HEAD.)) $ MAKE  22
  628                 LNSTRG = MXSTRG $                                                 MAKE  23
  629               END                                                                 MAKE  24
  630             FOR I = 0,1, (LNSTRG -1) / NBYTWD $                                   0806JB20
  631               LTEXT($ I $) = BLNK $                                               MAKE  26
  632             REMQUO (LNSTRG, NBYTWD = NWORDS, LASTBYT) $                           MAKE  27
  633             JJ = MXSTRG - LNSTRG $                                                MAKE  28
  634             KK = 0 $                                                              MAKE  29
  635     LOOP.   IF KK GQ NWORDS $ GOTO LAST $                                         MAKE  30
  636               BYTE($0,NBYTWD$) (LTEXT($ KK $)) =                                  MAKE  31
  637               BYTE($JJ,NBYTWD$) (STRNG ) $                                        MAKE  32
  638               KK = KK + 1 $                                                       MAKE  33
  639               JJ = JJ + NBYTWD $                                                  MAKE  34
  640             GOTO LOOP $                                                           MAKE  35
  641      LAST.                                                                        0715JB 1
  642             LENTXT = KK $                                                         0715JB 2
  643             IF LASTBYT GR 0 $                                                     0715JB 3
  644             BEGIN                                                                 0715JB 4
  645               BYTE($0,LASTBYTS$) (LTEXT($KK$)) = BYTE($JJ,LASTBYTS$) (STRNG) $0715JB 5
  646               LENTXT = LENTXT + 1 $                                               0715JB 6
  647             END                                                                   0715JB 7
  648            END                                                                    MAKE  39
  649
  650            PROC RRBAST (MODULE, STMT) $                                           PRBAST 3
```

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29061 82  05-01-78   14.801      JOVIAL COMPILATION OF SORCES            JOCIT VERSION 042275                 PAGE     14
   ALTER NO       ****5****1****5****2****5****3****5****4****5****5****5****6****5****7****5****8                    ANZ1
   651                  ''   JAVS-5  --  MODULE INSTRUMENTATION COMPONENT      ''           0729RU 6
   652                  ''      ''                                                          TEMP   1
   653                  ''PROBE ASSERT DIRECTIVE''                                          PRBAST 4
   654                  DEFINE DELI ''4H(DELI)'' $
   655                  DEFINE KEYW ''4H(KEYW)'' $
   656                  ITEM ASSLEN INTG $                                                  PRBAST 8
   657                 ITEM ASSTXT H 72$                                                    J3072410
   658                  ITEM FROM INTG $                                                    PRBAST 9
   659                  ITEM MODULE INTG $                                                  PRBAST10
   660                  ITEM STMT INTG $                                                    PRBAST11
   661                  ITEM TXTPTR INTG $                                                  PRBAST12
   662                  BEGIN                                                               PRBAST13
   663                    PRBDCL $   ''J.L. RAMEY, 4/1/78''
   664                 FROM = SCANUB (3,LENGTH+1,COMMA,DELI)$                               J3072411
   665                    BLDUIN(FROM+2, LENGTH-5, LLIST, 0, 72 0 INEXT, BUFOUT) $          PRBAST23
   666                 BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT)$                     J3072412
   667                 ASSTXT = JUSTRT (ASSTXT)$                                            J3072413
   668                 ASSLEN = LASTCH (ASSTXT)$                                            J3072414
   669                    TXTPTR = 0 $                                                      PRBAST26
   670                    BYTE($0,MAXTXT$) (TXTBUF) = BYTE($0,MAXTXT$) (BLANKS) $           0728JB 8
   671                 ADDTXT (8H(IF NOT (),8,TXTPTR=TXTPTR)$                               J3072415
   672                 ADDTXT (ASSTXT,ASSLEN,TXTPTR=TXTPTR)$                                J3072416
   673                 ADDTXT(3H() $),3,TXTPTR=TXTPTR)$                                     0728JB 9
   674                    TXTBUF = JUSTRT ( TXTBUF ) $                                      0721JB11
   675                    MAKE (MODULE, TXTBUF, TXTPTR, 0 0 LENTXT) $                       PRBAST33
   676                    STORRB (MODULE, DIRTV, LENTXT, LTEXT) $                           PRBAST34
   677                 TXTPTR = 0$                                                          0709CG59
   678                 BYTE($0,MAXTXT$) (TXTBUF) = BYTE($0,MAXTXT$) (BLANKS)$               0709CG60
   679                 ADDTXT (14H(JAVS'ASSERT = ),14,TXTPTR=TXTPTR)$                       J3072418
   680                    ADDTXT ( ITSHOL(ASSLEN+24), NBYTWD, TXTPTR = TXTPTR) $            0728JB10
   681                 ADDTXT (2H(M(),2,TXTPTR=TXTPTR)$                                     J3072420
   682                 ADDTXT (ASSTXT,ASSLEN,TXTPTR=TXTPTR)$                                J3072421
   683                 ADDTXT (10H( AT STMT, ),10,TXTPTR=TXTPTR)$                           J3072422
   684                 ADDTXT (ITSHOL(STMT),NBYTWD,TXTPTR=TXTPTR)$                          J3072423
   685                 ADDTXT (13H( NOT TRUE.) $),13,TXTPTR=TXTPTR)$                        0725JB 9
   686                    TXTBUF = JUSTRT ( TXTBUF ) $                                      0721JB12
   687                 MAKE (MODULE,TXTBUF,TXTPTR,0=LENTXT)$                                0709CG79
   688                 STORRB (MODULE,DIRTV,LENTXT,LTEXT)$                                  0709CG80
   689                  END ''PRBAST''                                                      PRBAST35
   690
   691              PROC PRBCHAIN (MODULE, STMT) $
   692              ''      JAVS-5  --  MODULE INSTRUMENTATION COMPONENT''
   693              ''      ''
   694              ''PROBE CHAIN DIRECTIVE  --  J.L. RAMEY, 2/24/78''
   695
   696              DEFINE IDENT ''4H(IDEN)'' $
   697              DEFINE DELI  ''4H(DELI)'' $
   698              DEFINE KEYH  ''4H(KEYH)'' $
   699              DEFINE RANGE ''4H(... )'' $
   700              DEFINE LPAREN ''4H((   )'' $
  ALTER NO        ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                   ANZ1

                  DEFINE MAXCSTK ''10'' $  ''SIZE OF ASSERTION COMMAND STACK''
                  ITEM ASSLEN INTG $
                  ITEM ASSTXT H 72 $
                  ITEM FROM INTG $
                  ITEM KEYWRD INTG $
                  ITEM MIDL INTG $
                  ITEM MODULE INTG $
                  ITEM STMT INTG $
                  ITEM TO INTG $
                  ITEM TMPTXT H 72 $
                  ITEM TXTPTR INTG $

                  BEGIN
                     ''SET UP MONITOR FOR ASSERTION VIOLATION OUTPUT''
                     PRBDCL $

                     ''INCREMENT AND CHECK COMMAND STACK PTR''
                     CSTKPTR = CSTKPTR + 1 $
                     IF CSTKPTR GQ MAXCSTK $
                        BEGIN
                           ERROR (33H(ASSERTION COMMAND STACK OVERFLOW)) $
                           RETURN $
                        END

                     ''CHECK FOR AND HANDLE EMPTY CLAUSE''
                     KEYWRD = SCANSB (3, LENGTH-5, 4H(EMPT), IDENT) $
                     IF (KEYWRD NQ -1) AND (LLIST($0,KEYWRD+1$) EQ 4H(Y    )) $
                        BEGIN ''FOUND AN EMPTY CLAUSE''
                        ''ISOLATE BOOLEAN EXPRESSION''
                           FROM = SCANSB (KEYWRD+2, LENGTH-1, LPAREN, DELI) $
                           TO = BALPAR (FROM+1, LENGTH, LLIST) $
                           BLDLIN (FROM+2, TO-1, LLIST, 0, 72 = INEXT, BUFOUT) $
                           BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
                           ASSTXT = JUSTRT (ASSTXT) $

                        ''BUILD IF NOT STMT''
                           TXTPTR = 0 $
                           BYTE ($0,MAXTXT$) (TXTBUF) = BYTE ($0,MAXTXT$) (BLANKS) $
                           ADDTXT (8H(IF NOT (), 8, TXTPTR = TXTPTR) $
                           ASSLEN = LASTCH (ASSTXT) $
                           ADDTXT (ASSTXT, ASSLEN, TXTPTR = TXTPTR) $
                           ADDTXT (3H() $), 3, TXTPTR = TXTPTR) $
                           TXTBUF = JUSTRT (TXTBUF) $
                           MAKE (MODULE, TXTBUF, TXTPTR, 0 = LENTXT) $
                           STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $
                        END

                     ''GENERATE BEGIN STMT''
                     MAKE (MODULE, 5H(BEGIN), 5, 0 = LENTXT) $
                     STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $
```

```
29067 82  05-01-78   18.881      JOVIAL COMPILATION OF SORCE5            JOCIT VERSION 042275               PAGE     16

  ALTER NO       ....5....1....5....2....5....3....5....4....5....5....5....5....6....5....7....5....8               ANZ1

               ''CHECK FOR AND HANDLE COUNT CLAUSE''
               KEYWRD = SCANSB (3, LENGTH-5, 4H(COUN), IDENT) $
               IFEITH (KEYWRD NQ -1) AND (LLIST($0,KEYWRD+1$) EQ 4H(T    )) $
                  BEGIN ''FOUND A COUNT CLAUSE''
                  ''IF FIRST COUNT CLAUSE, DECLARE ASSCNT''
                     IF NOT DCLASSCNT $
                        BEGIN
                           MAKE (MODULE, 20H(ITEM ASSCNT I 24 S $), 20, 0 = LENTXT)$
                           STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $
                           DCLASSCNT = TRUE $
                        END

                  ''BUILD COUNT INIT STMT''
                     MAKE (MODULE, 12H(ASSCNT = 0 $), 12, 0 = LENTXT) $
                     STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $

                  ''EXTRACT RANGE AND SAVE IN STACK''
                     FROM = SCANSB (KEYWRD+2, LENGTH-1, LPAREN, DELI) $
                     TO = BALPAR (FROM+1, LENGTH, LLIST) $
                     MIDL = SCANSB (FROM+1, TO-1, RANGE, DELI) $

                     ''MINIMUM COUNT''
                     BLDLIN (FROM+2, MIDL, LLIST, 0, 72 = INEXT, BUFOUT) $
                     BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
                     TMPTXT = JUSTRT (ASSTXT) $
                     ASSLEN = LASTCH (TMPTXT) $
                     BYTE ($0,ASSLEN$) (MINCNT ($CSTKPTR$)) = BYTE ($0,ASSLEN$)
                        (ASSTXT) $
                     LENMIN ($CSTKPTR$) = ASSLEN $

                     ''MAXIMUM COUNT''
                     BLDLIN (MIDL+2, TO-1, LLIST, 0, 72 = INEXT, BUFOUT) $
                     BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
                     TMPTXT = JUSTRT (ASSTXT) $
                     ASSLEN = LASTCH (TMPTXT) $
                     BYTE ($0,ASSLEN$) (MAXCNT ($CSTKPTR$)) = BYTE ($0,ASSLEN$)
                        (ASSTXT) $
                     LENMAX ($CSTKPTR$) = ASSLEN $
                  END
               ORIF 1 $ ''NO COUNT CLAUSE''
                  LENMIN ($CSTKPTR$) = 0 $
               END  ''IFEITHER''

               ''GET INDEX VARIABLE NAME - SAVE IN COMMAND STACK''
               FROM = SCANSB (3, LENGTH-1, LPAREN, DELI) $
               TO = BALPAR (FROM+1, LENGTH, LLIST) $
               BLDLIN (FROM+2, TO-1, LLIST, 0, 72 = INEXT, BUFOUT) $
               BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
               TMPTXT = JUSTRT (ASSTXT) $
```

```
ALTER NO      ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                ANZ1

              ASSLEN = LASTCH (TMPTXT) $
              BYTE ($0,ASSLEN$) (VARNAME($CSTKPTR$)) = BYTE ($0,ASSLEN$) (ASSTXT) $
              LENNAME ($CSTKPTR$) = ASSLEN $

              ''START BUILDING INDEX INIT STMT''
              TXTPTR = 0 $
              BYTE ($0,MAXTXT$) (TXTBUF) = BYTE ($0,MAXTXT$) (BLANKS) $
              ASSTXT = JUSTRT (ASSTXT) $
              ADDTXT (ASSTXT, ASSLEN, TXTPTR = TXTPTR) $
              ADDTXT (3H( = ), 3, TXTPTR = TXTPTR) $

              ''GET INITIAL VALUE - ADD IT TO STMT''
              KEYWRD = SCANSB (3, LENGTH-5, 4H(INIT), IDENT) $
              IFEITH (KEYWRD NQ -1) AND (LLIST($0,KEYWRD+1$) EQ 4H(    )) $
                 BEGIN ''FOUND INIT KEYWRD''
                    FROM = SCANSB (KEYWRD+2, LENGTH-1, LPAREN, DELI) $
                    TO = BALPAR (FROM+1, LENGTH, LLIST) $
                    BLDLIN (FROM+2, TO-1, LLIST, 0, 72 = NEXT, BUFOUT) $
                    BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
                    ASSTXT = JUSTRT (ASSTXT) $
                    ASSLEN = LASTCH (ASSTXT) $
                    ADDTXT (ASSTXT, ASSLEN, TXTPTR = TXTPTR ) $
                    ADDTXT (2H( $), 2, TXTPTR = TXTPTR) $
                    TXTBUF = JUSTRT (TXTBUF) $
                    MAKE (MODULE, TXTBUF, TXTPTR, 0 = LENTXT) $
                    STOPRB (MODULE, DIRTY, LENTXT, LTEXT) $
                 END
              ORIF 1 $
                 BEGIN ''NO INIT FIELD''
                    ERROR (38H(CHAIN ASSERTION ERROR - NO INIT FIELD.)) $
                    RETURN $
                 END
              END ''IFEITHER''

              ''GENERATE LABEL + SAVE IT IN COMMAND STACK''
              PRBLBL (STMT, 1H(0) = LABEL ($CSTKPTR$)) $
              LENLABL ($CSTKPTR$) = 6 $

              ''GENERATE LABEL STMT''
              BYTE ($0,MAXTXT$) (TXTBUF) = BYTE ($0,MAXTXT$) (BLANKS) $
              ASSLEN = LENLABL ($CSTKPTR$) $
              BYTE ($0,ASSLEN$) (TXTBUF) = BYTE ($0,ASSLEN$) (LABEL($CSTKPTR$)) $
              BYTE ($ASSLEN,1$) (TXTBUF) = 1H(.) $
              TXTBUF = JUSTRT (TXTBUF) $
              MAKE (MODULE, TXTBUF, ASSLEN+1, 0 = LENTXT) $
              STOPRB (MODULE, DIRTY, LENTXT, LTEXT) $

              ''CHECK FOR AND HANDLE BOUNDS CLAUSE''
              KEYWRD = SCANSB (3, LENGTH-5, 4H(BOUN), IDENT) $
              IFEITH (KEYWRD NQ -1) AND (LLIST($0,KEYWRD+1$) EQ 4H(DS  )) $
```

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2906T 02  05-01-78   11.801      JOVIAL COMPILATION OF SORCES          JOCIT VERSION 042275                  PAGE     18
   ALTER NO        ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                    ANZ1

                        BEGIN ''FOUND A BOUNDS CLAUSE''
                        ''ISOLATE LOWER AND UPPER BOUNDS''
                           FROM = SCANSB (KEYWRD+2, LENGTH-1, LPAREN, DELI) $
                           TO = BALPAR (FROM+1, LENGTH, LLIST) $
                           MIDL = SCANSB (FROM+1, TO-1, RANGE, DELI) $

                        ''BUILD APPROPRIATE IF STMT''
                           TXTPTR = 0 $
                           BYTE ($0,MAXTXT$) (TXTBUF) = BYTE ($0,MAXTXT$) (BLANKS) $
                           ADDTXT (8H(IF NOT (), 8, TXTPTR = TXTPTR) $
                           BLDLIN (FROM+2, MIDL, LLIST, 0, 72 = INEXT, BUFOUT) $
                           BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
                           ASSTXT = JUSTRT (ASSTXT) $
                           ASSLEN = LASTCH(ASSTXT) $
                           ADDTXT (ASSTXT, ASSLEN, TXTPTR = TXTPTR) $
                           ADDTXT (4H( LQ ), 4, TXTPTR = TXTPTR) $
                           ADDTXT (BYTE($0,LENNAME($CSTKPTR$)$) (VARNAME($CSTKPTR$)),
                              LENNAME($CSTKPTR$), TXTPTR = TXTPTR) $
                           ADDTXT (4H( LQ ), 4, TXTPTR = TXTPTR) $
                           BLDLIN (MIDL+2, TO-1, LLIST, 0, 72 = INEXT, BUFOUT) $
                           BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
                           ASSTXT = JUSTRT (ASSTXT) $
                           ASSLEN = LASTCH (ASSTXT) $
                           ADDTXT (ASSTXT, ASSLEN, TXTPTR = TXTPTR) $
                           ADDTXT (3H() $), 3, TXTPTR = TXTPTR) $
                           TXTBUF = JUSTRT (TXTBUF) $
                           MAKE (MODULE, TXTBUF, TXTPTR, 0 = LENTXT) $
                           STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $

                        ''BUILD BEGIN STMT''
                           MAKE (MODULE, 5H(BEGIN), 5, 0 = LENTXT) $
                           STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $

                        ''GENERATE STMT TO PRINT ERROR MESSAGE''
                           TXTPTR = 0 $
                           BYTE ($0,MAXTXT$) (TXTBUF) = BYTE ($0,MAXTXT$) (BLANKS) $
                           ADDTXT (49H(JAVS'ASSERT = 35H(BOUNDS ASSERTION ERROR AT STMT ),
                              49, TXTPTR = TXTPTR) $
                           ADDTXT (ITSHOL(STMT), NBYTWD, TXTPTR = TXTPTR) $
                           ADDTXT (3H() $), 3, TXTPTR = TXTPTR) $
                           TXTBUF = JUSTRT (TXTBUF) $
                           MAKE (MODULE, TXTBUF, TXTPTR, 0 = LENTXT) $
                           STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $

                        ''GENERATE AND SAVE LABEL FOR END OF LOOP''
                           PRELBL (STMT, 1H(E) = ELABEL ($CSTKPTR$)) $
                           LEVELBL ($CSTKPTR$) = 6 $

                        ''GENERATE GOTO ELABEL STMT''
                           BYTE ($0,MAXTXT$) (TXTBUF) = BYTE ($0,MAXTXT$) (BLANKS) $
```

```
ALTER NO     ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                          ANZ1
                  TXTPTR = 0 $
                  ADDTXT (5H(GOTO ), 5, TXTPTR = TXTPTR) $
                  ADDTXT (BYTE($0,LENELBL(SCSTKPTRS)$) (ELABEL(SCSTKPTRS)),
                     LENELBL(SCSTKPTRS), TXTPTR = TXTPTR) $
                  ADDTXT (2H( $), 2, TXTPTR = TXTPTR) $
                  TXTBUF = JUSTRT (TXTBUF) $
                  MARE (MODULE, TXTBUF, TXTPTR, 0 = LENTXT) $
                  STOPRB (MODULE, DIRTV, DENTXT, LTEXT) $

               ''GENERATE END STMT''
                  MARE (MODULE, 3H(END), 3, 0 = LENTXT) $
                  STOPRB (MODULE, DIRTV, DENTXT, LTEXT) $

               END
            ORIF 1 $ ''NO BOUNDS CLAUSE''
               LENELBL(SCSTKPTRS) = 0 $
            END

            ''IF COUNT CLAUSE, BUILD STMT TO INCR COUNT VARIABLE''
            IF LENMIN (SCSTKPTRS) NQ 0 $
               BEGIN ''COUNT CLAUSE''
                  MARE (MODULE, 21H(ASSCNT = ASSCNT + 1 $), 21, 0 = LENTXT) $
                  STOPRB (MODULE, DIRTV, DENTXT, LTEXT) $
               END

            ''ISOLATE NEXT FIELD AND SAVE IT IN COMMAND STACK''
            KEYWRD = SCANSB (3, LENGTH-1, 4H(NEXT), IDENT) $
            IFEITH (KEYWRD NQ -1) AND (LLIST($0,KEYWRD+1$) EQ 4H(    )) $
               BEGIN ''FOUND NEXT FIELD''
                  FROM = SCANSB (KEYWRD+2, LENGTH-1, LPAREN, DELI) $
                  TO = BALPAR (FROM+1, LENGTH, LLIST) $
                  BLDLIN (FROM+2, TO-1, LLIST, 0, 72 = NEXT, BUFOUT) $
                  BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
                  TMPTXT = JUSTRT (ASSTXT) $
                  ASSLEN = LASTCH (TMPTXT) $
                  BYTE ($0,ASSLEN$) (NEXTVAL(SCSTKPTRS)) = BYTE ($0,ASSLEN$)
                     (ASSTXT) $
                  LENNEXT (SCSTKPTRS) = ASSLEN $
               END
            ORIF 1 $ ''NO NEXT FIELD FOUND''
               BEGIN
                  ERROR (38H(CHAIN ASSERTION ERROR - NO NEXT FIELD.)) $
                  RETURN $
               END
            END

            ''ISOLATE END FIELD AND SAVE IT IN COMMAND STACK''
            KEYWRD = SCANSB (3, LENGTH-1, 4H(END ), KEYW) $
            IFEITH KEYWRD NQ -1 $
               BEGIN ''FOUND END FIELD''
```

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2906T 82  05-01-78   14.801      JOVIAL COMPILATION OF SORCE5          JOCIT VERSION 042275              PAGE     20
   ALTER NO      ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                ANZ1

                       FROM = SCANSB (KEYWRD$1$ LENGTH-1, LPARENT DEL!$ $
                       TO = BALPAR (FROM+1, LENGTH, LLIST) $
                       BLDLIN (FROM+2, TO-1, LLIST, 0, 72 = NEXT, BUFOUT) $
                       BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
                       THRTXT = JUSTRT (ASSTXT) $
                       ASSLEN = LASTCH (TMPTXT) $
                       BYTE ($0,ASSLEN$) (EXIT($CSTKPTR$)) = BYTE ($0,ASSLEN$)
                          (ASSTXT) $
                       LENEXIT ($CSTKPTR$) = ASSLEN $
                    END
                 ORIF 1 $ ''NO END FIELD FOUND''
                    BEGIN
                       ERROR (37H(CHAIN ASSERTION ERROR - NO END FIELD;)) $
                       RETURN $
                    END
                 END
              END ''PRBCHAIN''

              PROC PRBENDS (MODULE, STMT) $
              ''      JAVS#5  -4  MODULE INSTRUMENTATION COMPONENT''
              ''      ''
              ''PROBE ENDCHAIN AND ENDLOOP DIRECTIVES  --  J.L.RAMBY, 3/6/78''

              ITEM ASSLEN INTG $
              ITEM ASSTXT H 72 $
              ITEM MODULE INTG $
              ITEM STMT INTG $
              ITEM TXTPTR INTG $

              BEGIN
                 ''CHECK TO MAKE SURE STACK IS NOT EMPTY''
                 IF CSTKPTR LQ -1 $
                    BEGIN
                       ERROR (34H(ASSERTION COMMAND STACK UNDERFLOW.)) $
                       RETURN $
                    END

                 ''GENERATE LOOPING STATEMENTS''
                    ''ASSIGN NEW VALUE TO INDEX''
                       TXTPTR = 0 $
                       BYTE ($0,MAXTXT$) (TXTBUF) = BYTE ($0,MAXTXT$) (BLANKS) $
                       BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BLANKS) $
                       ASSLEN = LENNAME ($CSTKPTR$) $
                       BYTE ($0,ASSLEN$) (ASSTXT) = BYTE ($0,ASSLEN$)
                          (VARNAME ($CSTKPTR$)) $
                       ADDTXT (JUSTRT(ASSTXT), ASSLEN, TXTPTR = TXTPTR) $
                       ADDTXT (3H( = ), 3, TXTPTR = TXTPTR) $
                       BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BLANKS) $
                       ASSLEN = LENNEXT ($CSTKPTR$) $
                       BYTE ($0,ASSLEN$) (ASSTXT) = BYTE ($0,ASSLEN$)
```

```
ALTER NO     ....$....1....5....2....$....3....$....4....$....5....$....6....$....7....$....8        AN21

                  (NEXTVAL ($CSTKPTRS)) $
                ADDTXT (JUSTRT(ASSTXT), ASSLEN, TXTPTR = TXTPTR) $
                ADDTXT (2H( $), 2, TXTPTR = TXTPTR) $
                MAKE (MODULE, JUSTRT(TXTBUF), TXTPTR, 0 = LENTXT) $
                STOPRB (MODULE, DIRTV, UENTXT, LTEXT) $

            ''CHECK FOR EXIT CONDITION''
                TXTPTR = 0 $
                BYTE ($0,MAXTXTS) (TXTBUF) = BYTE ($0,MAXTXTS) (BLANKS) $
                ADDTXT (8H(IF NOT (), 8, TXTPTR = TXTPTR) $
                BYTE ($0,72S) (ASSTXT) = BYTE ($0,72S) (BLANKS) $
                ASSLEN = LENEXIT ($CSTKPTRS) $
                BYTE ($0,ASSLENS) (ASSTXT) = BYTE ($0,ASSLENS)
                  (EXIT ($CSTKPTRS)) $
                ADDTXT (JUSTRT(ASSTXT), ASSLEN, TXTPTR = TXTPTR) $
                ADDTXT (3H() $), 3, TXTPTR = TXTPTR) $
                MAKE (MODULE, JUSTRT(TXTBUF), TXTPTR, 0 = LENTXT) $
                STOPRB (MODULE, DIRTV, UENTXT, LTEXT) $

            ''BRANCH TO TOP OF LOOP''
                TXTPTR = 0 $
                BYTE ($0,MAXTXTS) (TXTBUF) = BYTE ($0,MAXTXTS) (BLANKS) $
                ADDTXT (5H(GOTO ), 5, TXTPTR = TXTPTR) $
                BYTE ($0,72S) (ASSTXT) = BYTE ($0,72S) (BLANKS) $
                ASSLEN = LENLABL ($CSTKPTRS) $
                BYTE ($0,ASSLENS) (ASSTXT) = BYTE ($0,ASSLENS)
                  (LABEL ($CSTKPTRS)) $
                ADDTXT (JUSTRT(ASSTXT), ASSLEN, TXTPTR = TXTPTR) $
                ADDTXT (2H( $), 2, TXTPTR = TXTPTR) $
                MAKE (MODULE, JUSTRT(TXTBUF), TXTPTR, 0 = LENTXT) $
                STOPRB (MODULE, DIRTV, UENTXT, LTEXT) $

          ''IF BOUNDS CLAUSE, THEN ADD END-OF-LOOP LABEL''
          IF LENELBL ($CSTKPTRS) NQ 0 $
            BEGIN
                TXTPTR = 0 $
                BYTE ($0,MAXTXTS) (TXTBUF) = BYTE ($0,MAXTXTS) (BLANKS) $
                BYTE ($0,72S) (ASSTXT) = BYTE ($0,72S) (BLANKS) $
                ASSLEN = LENELBL ($CSTKPTRS) $
                BYTE ($0,ASSLENS) (ASSTXT) = BYTE ($0,ASSLENS)
                  (ELABEL ($CSTKPTRS)) $
                ADDTXT (JUSTRT(ASSTXT), ASSLEN, TXTPTR = TXTPTR) $
                ADDTXT (1H(.), 1, TXTPTR = TXTPTR) $
                MAKE (MODULE, JUSTRT(TXTBUF), TXTPTR, 0 = LENTXT) $
                STOPRB (MODULE, DIRTV, UENTXT, LTEXT) $
            END

          ''IF COUNT CLAUSE, THEN ADD CHECK STMTS''
          IF LENMIN ($CSTKPTRS) NQ 0 $
            BEGIN
```

```
ALTER NO     ....$....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                ANZ1
               ''GENERATE CHECK STMT''
                  TXTPTR = 0 $
                  BYTE ($0,MAXTXTS) (TXTBUF) = BYTE ($0,MAXTXTS) (BLANKS) $
                  ADDTXT (8H(IF NOT (), 8, TXTPTR = TXTPTR) $
                  BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BLANKS) $
                  ASSLEN = LENMIN ($CSTKPTR$) $
                  BYTE ($0,ASSLEN$) (ASSTXT) = BYTE ($0,ASSLEN$)
                     (MINCNT ($CSTKPTR$)) $
                  ADDTXT (JUSTRT(ASSTXT), ASSLEN, TXTPTR = TXTPTR) $
                  ADDTXT (14H) LQ ASSONT UQ ), 14, TXTPTR = TXTPTR) $
                  BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BLANKS) $
                  ASSLEN = LENMAX ($CSTKPTR$) $
                  BYTE ($0,ASSLEN$) (ASSTXT) = BYTE ($0,ASSLEN$)
                     (MAXCNT ($CSTKPTR$)) $
                  ADDTXT (JUSTRT(ASSTXT), ASSLEN, TXTPTR = TXTPTR) $
                  ADDTXT (3H() $), 3, TXTPTR = TXTPTR) $
                  MAKE (MODULE, JUSTRT(TXTBUF), TXTPTR, 0 = LBNTXT) $
                  STOPRB (MODULE, DIRTV, DENTXT, LTEXT) $

               ''GENERATE STMT TO PRINT ERROR MESSAGE''
                  TXTPTR = 0 $
                  BYTE ($0,MAXTXTS) (TXTBUF) = BYTE ($0,MAXTXTS) (BLANKS) $
                  ADDTXT (48H(JAVS'ASSERT = 34H(COUNT ASSERTION ERROR AT STMT ),
                     48, TXTPTR = TXTPTR) $
                  ADDTXT (ITSHOL(STMT), NBYTHO, TXTPTR = TXTPTR) $
                  ADDTXT (3H() $), 3, TXTPTR = TXTPTR) $
                  MAKE (MODULE, JUSTRT(TXTBUF), TXTPTR, 0 = LBNTXT) $
                  STOPRB (MODULE, DIRTV, DENTXT, LTEXT) $
               END

            ''ADD END STMT''
            MAKE (MODULE, 3H(END), 3, 0 = LBNTXT) $
            STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $

            ''DECREMENT COMMAND STACK PTR''
            CSTKPTR = CSTKPTR - 1 $

         END ''PRBENDC''

               PROC PRBDIR (MODULE, STMT) $                                   PRBDIR 3
               ''      JAVS-5  --  MODULE INSTRUMENTATION COMPONENT      ''      0729RU 6
               ''      ''                                                     TEMP   1
               ''RECOGNIZES THE TYPE OF DIRECTIVE AND INVOKES THE              PRBDIR 4
                  PARTICULAR ROUTINE TO IMPLEMENT THE DIRECTIVE''             PRBDIR 5
               ITEM MODULE INTG $                                             PRBDIR 8
               ITEM STMT INTG $                                               PRBDIR 9
               BEGIN  ''PRBDIR''                                              PRBDIR10
                  ''STORE DIRECTIVE IN INSTRUMENTED TEXT TABLE''              PRBDIR11
               IF BEGST OR 0$                                                 0725JB 7
               STOLBL (MODULE)$                                               0725JB 8
```

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2906T 62  05-01-78   14.801      JOVIAL COMPILATION OF SORCE5          JOCIT VERSION 042275              PAGE     23

   ALTER NO       8....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8               AN21

  1101                   STO$B (MODULE, STMT) $                                               PRBDIR12
  1102                 HTEMP = BLNKS                                                          0709CG43
  1103                 BYTE($0;NBYTHDS)(HTEMP) = BYTE($0;NBYTHDS)(LLIST($0/1$))$              0709CG44
  1104                   IFEITH HTEMP EQ 4H(ASSE)$                                            0709CG47
  1105                     PRBAST (MODULE, STMT) $                                            PRBDIR14
  1106                   ORIF HTEMP EQ 4H(TRAC)$                                              0709CG48
  1107                     PRBTDR (MODULE, STMT) $                                            PRBDIR16
  1108                   ORIF HTEMP EQ 4H(OFFT)$                                              0709CG49
  1109                     PRBOFT (MODULE, STMT) $                                            PRBDIR18
  1110                   ORIF HTEMP EQ 4H(EXPE)$                                              0709CG50
  1111                     PRBXPT (MODULE, STMT) $                                            PRBDIR20
  1112                   ORIF HTEMP EQ 4H(JAVS)$                                              JB0724 8
  1113                     RETURNS                                                            JB0724 9
  1114                   ORIF HTEMP EQ 4H(CHAI) $
  1115                       PRBCHAIN (MODULE, STMT) $
  1116                   ORIF HTEMP EQ 4H(ENDC) $
  1117                       PRBENDC (MODULE, STMT) $
  1118                   ORIF HTEMP EQ 4H(LOOP) $
  1119                       PRBLOOP (MODULE, STMT) $
  1120                   ORIF HTEMP EQ 4H(ENDL) $
  1121                       PRBENDC (MODULE, STMT) $
  1122                   ORIF HTEMP EQ 4H(VALU) $
  1123                       PRBVALUE (MODULE, STMT) $
  1124                   ORIF 1 $                                                             PRBDIR81
  1125                       ERROR (25H(DIRECTIVE NOT RECOGNIZED.) ) $                        PRBDIR83
  1126                   END                                                                  PRBDIR86
  1127                 END   ''PRBDIR''                                                       PRBDIR87
  1128
  1129              PROC PRBLOOP (MODULE, STMT) $
  1130              ''    JAVS-3  --  MODULE INSTRUMENTATION COMPONENT''
  1131              ''      ''
  1132              ''PROBE LOOP DIRECTIVE  --  J.W. RAMEY, 2/16/78''
  1133
  1134              DEFINE DELI ''4H(DELI)'' $
  1135              DEFINE IDENT ''4H(IDEN)'' $
  1136              DEFINE LPAREN ''4H((   )'' $
  1137              DEFINE RANGE ''4H(.:  )'' $
  1138              DEFINE MAXCSTK ''10'' $ ''SIZE OF ASSERTION COMMAND STACK''
  1139              ITEM ASSLEN INTG $
  1140              ITEM ASSTXT H 72 $
  1141              ITEM FROM INTG $
  1142              ITEM KEYWRD INTG $
  1143              ITEM MITL INTG $
  1144              ITEM MODULE INTG $
  1145              ITEM STMT INTG $
  1146              ITEM TO INTG $
  1147              ITEM TXTPTR INTG $
  1148              ITEM VARLEN INTG $
  1149              ITEM VARTXT H 72 $
  1150
```

```
29061 02  05-01-78   14.801      JOVIAL COMPILATION OF SORCES          UOCIT VERSION 042275              PAGE      24
   ALTER NO        0....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8           ANZ1

    1151              BEGIN
    1152                 ''SET UP MONITOR FOR ASSERTION VIOLATION OUTPUT''
    1153                 PABDOL $
    1154
    1155                 ''INCREMENT AND CHECK COMMAND STACK PTR''
    1156                 CSTKPTR = CSTKPTR + 1 $
    1157                 IF CSTKPTR GQ MAXCSTK $
    1158                    BEGIN
    1159                       ERROR (33H(ASSERTION COMMAND STACK OVERFLOW)) $
    1160                       RETURN $
    1161                    END
    1162
    1163                 ''CHECK FOR AND HANDLE EMPTY CLAUSE''
    1164                 KEYWRD = SCANSB (3, LENGTH-5, 4H(EMPT), IDENT) $
    1165                 IF (KEYWRD NQ -1) AND (LLIST($0,KEYWRD+1$) EQ 4H(T    )) $
    1166                    BEGIN ''FOUND AN EMPTY CLAUSE''
    1167                    ''ISOLATE BOOLEAN EXPRESSION''
    1168                       FROM = SCANSB (KEYWRD+2, LENGTH+1, LPAREN, DELI) $
    1169                       TO = BALPAR (FROM+1, LENGTH, LLIST) $
    1170                       BLDLIN (FROM+2, TO-1, LLIST, 0, 72 = INEXT, BUFOUT) $
    1171                       BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
    1172                       ASSTXT = JUSTRT (ASSTXT) $
    1173
    1174                    ''BUILD IF NOT STMT''
    1175                       TXTPTR = 0 $
    1176                       BYTE ($0,MAXTXT$) (TXTBUF) = BYTE ($0,MAXTXT$) (BLANKS) $
    1177                       ADDTXT (8H(IF NOT (), 8 = TXTPTR = TXTPTR) $
    1178                       ASSLEN = LASTCH (ASSTXT) $
    1179                       ADDTXT (ASSTXT, ASSLEN, TXTPTR = TXTPTR) $
    1180                       ADDTXT (3H() $), 3, TXTPTR = TXTPTR) $
    1181                       TXTBUF = JUSTRT (TXTBUF) $
    1182                       MAKE (MODULE, TXTBUF, TXTPTR, 0 = LENTXT) $
    1183                       STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $
    1184                    END
    1185
    1186                 ''GENERATE BEGIN STMT''
    1187                 MAKE (MODULE, 5H(BEGIN), 5, 0 = LENTXT) $
    1188                 STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $
    1189
    1190                 ''ISOLATE INDEX VARIABLE AND SAVE IT ON STACK''
    1191                 FROM = SCANSB (3, LENGTH-1, LPAREN, DELI) $
    1192                 TO = BALPAR (FROM+1, LENGTH, LLIST) $
    1193                 BLDLIN (FROM+2, TO-1, LLIST, 0, 72 = INEXT, BUFOUT) $
    1194                 BYTE ($0,72$) (VARTXT) = BYTE ($0,72$) (BUFOUT) $
    1195                 ASSTXT = JUSTRT (VARTXT) $
    1196                 VARLEN = LASTCH (ASSTXT) $
    1197                 BYTE ($0,VARLEN$) (VARNAME ($CSTKPTR$)) = BYTE ($0,VARLEN$) (VARTXT)$
    1198                 LENNAME ($CSTKPTR$) = VARLEN $
    1199
    1200                 ''SAVE NEXT VALUE ON STACK''
```

```
200ST 02  05-01-78    14.801      JOVIAL COMPILATION OF SORCE5              JOCIT VERSION 042275                     PAGE     25

   ALTER NO         ****5****1****5****2****5****3****5****4****5****5****5****6****5****7****5****8                ANZ1

  1201                TXTPTR = 0 $
  1202                BYTE ($0,MAXTXTS) (TXTBUF) = BYTE ($0,MAXTXTS) (BLANKS) $
  1203                VARTXT = JUSTRT (VARTXT) $
  1204                ADDTXT (VARTXT, VARLEN, TXTPTR = TXTPTR) $
  1205                ADDTXT (4H( + 1), 4, TXTPTR = TXTPTR) $
  1206                BYTE ($0,TXTPTRS) (NEXTVAL ($CSTKPTRS)) = BYTE ($1,TXTPTRS) (TXTBUF)$
  1207                LENNEXT ($CSTKPTRS) = TXTPTR $
  1208
  1209                ''ISOLATE INITIAL AND FINAL VALUES''
  1210                FROM = SCANSB (TO, LENGTH-1, UPAREN, DELI) $
  1211                TO = BALPAR (FROM+1, LENGTH, LLIST) $
  1212                MIDL = SCANSB (FROM+1, TO-1, RANGE, DELI) $
  1213
  1214                ''GENERATE INITIALIZATION STMT FOR INDEX VARIABLE''
  1215                TXTPTR = 0 $
  1216                BYTE ($0,MAXTXTS) (TXTBUF) = BYTE ($0,MAXTXTS) (BLANKS) $
  1217                ADDTXT (VARTXT, VARLEN, TXTPTR = TXTPTR) $
  1218                ADDTXT (3H( = ), 3, TXTPTR = TXTPTR) $
  1219                BLDLIN (FROM+2, MIDL, LLIST, 0, 72 = NEXT, BUFOUT) $
  1220                BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
  1221                ASSTXT = JUSTRT (ASSTXT) $
  1222                ASSLEN = LASTCH (ASSTXT) $
  1223                ADDTXT (ASSTXT, ASSLEN, TXTPTR = TXTPTR) $
  1224                ADDTXT (2H( $), 2, TXTPTR = TXTPTR) $
  1225                TXTBUF = JUSTRT (TXTBUF) $
  1226                MAKE (MODULE, TXTBUF, TXTPTR, 0 = LENTXT) $
  1227                STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $
  1228
  1229                ''SAVE EXIT CONDITION ON STACK''
  1230                TXTPTR = 0 $
  1231                BYTE ($0,MAXTXTS) (TXTBUF) = BYTE ($0,MAXTXTS) (BLANKS) $
  1232                ADDTXT (VARTXT, VARLEN, TXTPTR = TXTPTR) $
  1233                ADDTXT (4H( GR ), 4, TXTPTR = TXTPTR) $
  1234                BLDLIN (MIDL+2, TO-1, LLIST, 0, 72 = NEXT, BUFOUT) $
  1235                BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
  1236                ASSTXT = JUSTRT (ASSTXT) $
  1237                ASSLEN = LASTCH (ASSTXT) $
  1238                ADDTXT (ASSTXT, ASSLEN, TXTPTR = TXTPTR) $
  1239                BYTE ($0,TXTPTRS) (EXIT ($CSTKPTRS)) = BYTE ($1,TXTPTRS) (TXTBUF) $
  1240                LENEXIT ($CSTKPTRS) = TXTPTR $
  1241
  1242                ''GENERATE LABEL = SAVE IT IN COMMAND STACK''
  1243                PRBLBL (STMT, 1H(0) = LABEL ($CSTKPTRS)) $
  1244                LENLABL ($CSTKPTRS) = 6 $
  1245
  1246                ''GENERATE LABEL STMT''
  1247                BYTE ($0,MAXTXTS) (TXTBUF) = BYTE ($0,MAXTXTS) (BLANKS) $
  1248                ASSLEN = LENLABL ($CSTKPTRS) $
  1249                BYTE ($0,ASSLENS) (TXTBUF) = BYTE ($0,ASSLENS) (LABEL($CSTKPTRS)) $
  1250                BYTE ($ASSLEN,1$) (TXTBUF) = 1H(.) $
  ALTER NO      ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8              ANZ1

                   TXTBUF = JUSTRT (TXTBUF) $
                   MAKE (MODULE, TXTBUF, ASSLEN+8, 0 = LENTXT) $
                   STOPRB (MODULE, DIRTV, LENTXT8 LTEXT) $

                   ''SET OPTIONS AS NOT USED''
                   LENELBL (SCSTKPTRS) = 0 $
                   LENMIN (SCSTKRTRS) = 0 $

                END ''PRBLOOP''

                PROC PRBVALUE (MODULE, STMT) $
                ''      JAVS15  --  MODULE INSTRUMENTATION''
                ''      ''
                ''PROBE ASSERT VALUE/NOT VALUE DIRECTIVES''

                DEFINE COMMA ''4H(,   )'' $
                DEFINE DELI ''4H(DEL()'' $
                DEFINE IDENT ''4H(IDEN)'' $
                DEFINE OPER ''4H(OPER)'' $
                DEFINE RANGE ''4H(...)'' $
                DEFINE LPAREN ''4H((   )'' $

                ITEM ASSLEN INTG $
                ITEM ASSTXT H 72 $
                ITEM FROM INTG $
                ITEM MIDL INTG $
                ITEM MODULE INTG $
                ITEM RPAREN INTG $
                ITEM STMT INTG $
                ITEM TO INTG $
                ITEM TXTPTR INTG $
                ITEM VARLEN INTG $
                ITEM VARTXT H 72 $

                BEGIN
                   ''SET UP MONITOR FOR ASSERTION VIOLATION OUTPUT''
                   PRBDOL $

                   ''BUILD TEXT STRING CONTAINING VARIABLE NAME''
                   FROM = SCANSB (3, LENGTH-1, LPAREN, DELI) $
                   TO = BALRAR (FROM+1, LENGTH, LLIST) $
                   BLDLIN (FROM+2, TO-1, LLIST, 0, 72 = INEXT, BUFOUT) $
                   BYTE ($0,72$) (VARTXT) = BYTE ($0,72$) (BUFOUT) $
                   VARTXT = JUSTRT (VARTXT) $
                   VARLEN = LASTCH (VARTXT) $

                   ''START BUILDING IF STMT''
                   TXTPTR = 0 $
                   BYTE ($0,MAXTXT$) (TXTBUF) = BYTE ($0,MAXTXT$) (BLANKS) $
                   ADDTXT (3H(IF ), 3, TXTPTR = TXTPTR) $
```

```
2906T 82  05-01-78   14.801      JOVIAL COMPILATION OF SORCES            UOCIT VERSION 042275                 PAGE     27
  ALTER NO      ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8              ANZ1

                  ''CHECK FOR 'NOT' BETWEEN VARIABLE AND VALUES,
                  NEGATE SENSE OF DIRECTIVE IN IF STMT.''
                  IF LLIST ($0,TO$) NQ 4H(NOT ) $
                     ADDTXT (4H(NOT ), 4, TXTPTR = TXTPTR) $

                  ''INSERT LPAREN TO SURROUND TOTAL EXPRESSION''
                  ADDTXT (1H((), 1, TXTPTR = TXTPTR) $

                  ''FIND PARENS SURROUNDING VALUES''
                  FROM = SCANSB (TO, LENGTH-1, LPAREN, DELI) $ ''INDEX VALUE''
                  RPAREN = BALPAR (FROM+1, LENGTH, LLIST) - 1 $ ''INDEX VALUE''

                  ''LOOP FOR EACH VALUE OR RANGE IN THE LIST''
                VALULOOP.
                     ADDTXT (1H((), 1, TXTPTR = TXTPTR) $

                     ''LOOK FOR COMMA SEPERATING NEXT VALUE''
                        TO = SCANSB (FROM+1, LENGTH-1, COMMA, DELI) $ ''INDEX VALUE''
                        IF (TO EQ -1) OR (TO GR RPAREN) $
                           ''LAST VALUE OR RANGE''
                           TO = RPAREN $

                     ''LOOK FOR RANGE INDICATOR''
                        MIDL = SCANSB (FROM+1, TO-1, RANGE, DELI) $

                     IFEITH MIDL EQ -1 $
                        BEGIN ''SIMPLE VALUE - BUILD CORRECT BOOLEAN EXPR.''
                           PRBCHKL (MODULE, VARLEN, TXTPTR = TXTPTR) $
                           ADDTXT (VARTXT, VARLEN, TXTPTR = TXTPTR) $
                           BLDLIN (FROM+2, TO, ULIST, 0, 72 = INEXT, BUFOUT) $
                           BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
                           ASSTXT = JUSTRT (ASSTXT) $
                           ASSLEN = LASTCH (ASSTXT) $
                           PRBCHKL (MODULE, ASSLEN+4, TXTPTR = TXTPTR) $
                           ADDTXT (4H( EQ ), 4, TXTPTR = TXTPTR) $
                           ADDTXT (ASSTXT, ASSLEN, TXTPTR = TXTPTR) $
                        END
                     ORIF 1 $
                        BEGIN ''RANGE - BUILD CORRECT BOOLEAN EXPR.''
                           ''INSERT TEXT FOR LOW BOUND''
                              BLDLIN (FROM+2, MIDL, LLIST, 0, 72 = INEXT, BUFOUT) $
                              BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
                              ASSTXT = JUSTRT (ASSTXT) $
                              ASSLEN = LASTCH (ASSTXT) $
                              PRBCHKL (MODULE, ASSLEN, TXTPTR = TXTPTR) $
                              ADDTXT (ASSTXT, ASSLEN, TXTPTR = TXTPTR) $

                           PRBCHKL (MODULE, VARLEN+4, TXTPTR = TXTPTR) $
                           ADDTXT (4H( LQ ), 4, TXTPTR = TXTPTR) $
```

```
   ALTER NO      V....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                ANZ1
                           ADDTXT (VARTXT, VARLEN, TXTPTR = TXTPTR) $

                           ''INSERT TEXT FOR HIGH BOUND''
                              BLDLIN (MIDL+2, TO; LLIST; 0, 72 $ INEXT, BUFOUT) $
                              BYTE ($0,72$) (ASSTXT) = BYTE ($0,72$) (BUFOUT) $
                              ASSTXT = JUSTRT (ASSTXT) $
                              ASSLEN = LASTCH (ASSTXT) $
                              PRBCHKL (MODULE, ASSLEN+4, TXTPTR = TXTPTR) $
                              ADDTXT (4H( LO ), 4, TXTPTR = TXTPTR) $
                              ADDTXT (ASSTXT, ASSLEN, TXTPTR = TXTPTR) $
                     END
                 END ''IFEITHER''

                 PRBCHKL (MODULE, 1; TXTPTR = TXTPTR) $
                 ADDTXT (1H)), 1, TXTPTR = TXTPTR) $

                 IF TO NQ RPAREN $
                     BEGIN ''MORE VALUES OR RANGES TO DO''
                        PRBCHKL (MODULE, 5, TXTPTR = TXTPTR) $
                        ''ALSO INCLUDES ROOM FOR NEXT OPEN PARENS.''
                        ADDTXT (4H( OR ), 4, TXTPTR = TXTPTR) $
                        FROM = TO $
                        GOTO VALULOOP $
                     END

              ''TERMINATE IF STMT''
                 PRBCHKL (MODULE, 3; TXTPTR = TXTPTR) $
                 ADDTXT (3H() $), 3; TXTPTR = TXTPTR) $
                 MAKE (MODULE; JUSTRT(TXTBUF), TXTPTR, 0 = LENTXT) $
                 STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $

              ''ADD STMT TO PRINT ERROR MESSAGE''
                 TXTPTR = 0 $
                 BYTE ($0,MAXTXT$) (TXTBUF) = BYTE ($0,MAXTXT$) (BLANKS) $
                 ADDTXT (48H(JAVS'ASSERT $ 34H(VALUE ASSERTION ERROR AT STMT ),
                    48; TXTPTR = TXTPTR) $
                 ADDTXT (ITSHOL(STMT), NBYTWD, TXTPTR = TXTPTR) $
                 ADDTXT (3H() $), 3, TXTPTR = TXTPTR) $
                 TXTBUF = JUSTRT (TXTBUF) $
                 MAKE (MODULE; TXTBUF, TXTPTR, 0 = LENTXT) $
                 STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $

           END ''PRBVALUE''

           PROC PRBCHKL (MODULE, CHARS, LENGTH = NEW'LENGTH) $
           ''     JAVS45  --  MODULE INSTRUMENTATION COMPONENT''
           ''     ''
           ''     CHECKS TO MAKE SURE STRING OF LENGTH 'CHARS' CAN BE ADDED TO
                  TXTBUF WHICH ALREADY CONTAINS A STRING OF LENGTH 'LENGTH'.
                  IF NOT, THE CURRENT CONTENTS OF TXTBUF ARE WRITTEN OUT
```

```
29061 82  05-01-78   14.801     JOVIAL COMPILATION OF SORCES          JOCIT VERSION 042275              PAGE     29

  ALTER NO        0....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                  ANZ1

                      AND THE BUFFER IS CLEARED?  'NEW'LENGTH' IS THE LENGTH OF
                      THE STRING LEFT IN TXTBUF AT THE END OF THE PROC.''

                 ITEM CHARS INTG $
                 ITEM LENGTH INTG $
                 ITEM MODULE INTG $
                 ITEM NEW'LENGTH INTG $

                 BEGIN
                    NEW'LENGTH = LENGTH $
                    IF LENGTH+CHARS GR MAXTXT $
                       BEGIN
                          TXTBUF = JUSTRT (TXTBUF) $
                          MAKE (MODULE, TXTBUF, LENGTH, 0 = LENTXT) $
                          STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $
                          NEW'LENGTH = 0 $
                          BYTE ($0,MAXTXT$) (TXTBUF) = BYTE ($0,MAXTXT$) (BLANKS) $
                       END

                 END ''PRBCHRL''

                 PROC PRBDCL $
                 ''      JAVS-5  --  MODULE INSTRUMENTATION COMPONENT''
                 ''      ''
                 ''SET UP MONITOR FOR OUTPUTTING ASSERTION VIOLATION MESSAGES''
                 ''       J.L. RAMEY, 4/1/78''

                 BEGIN
                    IF NOT DECLARED $
                    BEGIN
                       MAKE (MODULE, 23H(ITEM JAVS'ASSERT H 72 $)( 23, 0 = LENTXT)$
                       STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $
                       MAKE (MODULE, 21H(MONITOR JAVS'ASSERT $), 21, 0 = LENTXT) $
                       STOPRB (MODULE, DIRTV, LENTXT, LTEXT) $
                       DECLARED = TRUE $
                    END
                    END ''PRBDCL''

                 PROC PRBLBL (STMT, NO = LABEL) $
                 ''      JAVS-5  --  MODULE INSTRUMENTATION COMPONENT''
                 ''      ''
                 ''GENERATE A SIX CHARACTER LABEL USING A STMT NUMBER (STMT) AND
                 CALLER SPECIFIED 1-DIGIT NUMBER (NO). ''
                 ''      J.L. RAMEY, 4/1/78''

                 ITEM LABEL H 6 $
                 ITEM NO H 1 $
                 ITEM STMT INTG $

                 BEGIN
```

```
29081 82  05-01-78   14.801     JOVIAL COMPILATION OF SORCES          UOCIT VERSION 042275                PAGE     30
   ALTER NO    ....5....1....5....2....5....3....5....4....5....5....5....6....5....7....5....8                ANZ1
                  BYTE ($0,1$) (LABEL) = 1H(J) $
                  BYTE ($1,4$) (LABEL) = ITSHOL (STMT) $
                  BYTE ($5,1$) (LABEL) = NO $

                  ''CHANGE SPACES TO ZEROES IN STMT NO.''
                  FOR I = 1, 1, 4 $
                  BEGIN
                     IF BYTE ($I,1$) (LABEL) EQ 1H( ) $
                        BYTE ($I,1$) (LABEL) = 1H(0) $
                  END

              END ''PRBLBL''

                     PROC PRBEF (MODULE, STMT) $                                         PRBEF  3
                     ''     JAVS-3  --  MODULE INSTRUMENTATION COMPONENT       ''        0729RU 6
                     ''        ''                                                        TEMP   1
                     '' PROBE END OF IFEITH STATEMENT ''                                 PRBEF  4
                     ITEM LENTXT INTG $      ''CURRENT LENGTH OF LTEXT ARRAY''           PRBEF  7
                     ITEM MARK INTG $        ''STATEMENT NUMBER OF 1ST ORIF IN NEST''    PRBEF  8
                     ITEM MODULE INTG $      ''MODULE NUMBER''                           PRBEF  9
                     ITEM PTR INTG $   '' POINTER TO NEXT CONTROL STATEMENT IN IFEITH''PRBEF 10
                     ITEM STMT INTG $        ''CURRENT STATEMENT NUMBER''                PRBEF 11
                     ITEM SB INTG $  '' STATEMENT BLOCK NUMBER ''                        PRBEF 12
                     ITEM UJ INTG $                                                      PRBEF 13
                     BEGIN                                                               PRBEF 23
                       ''                                                            ''  PRBEF 24
                       ''********** CHECK FOR ORIF 1 IN NEST ***********''               PRBEF 25
                       ''                                                            ''  PRBEF 26
                       MARK = CASE2(MODULE, STMT) $                                      PRBEF 27
                       ''SEARCH IFEITH/ORIF FOR ORIF1''                                  PRBEF 28
                       SB = MARK $                                                       PRBEF 29
                GETPTR.                                                                  PRBEF 30
                       PTR = IGTWRD(MODULE, SDBNUM, SB, 7) $                             PRBEF 31
                       ITYPE = IGTWRD(MODULE, SDBNUM, PTR, 8) $                          PRBEF 32
                       IF ITYPE EQ 300 $        ''ORIF 1 PRESENT -- DON'T PROBE''        PRBEF 33
                         BEGIN                  ''UNSTACK FALSE BRANCH DD-PATHS''        PRBEF 34
                UNSTACK.                                                                 PRBEF 35
                            IF LASTIF LQ 0 $                                             PRBEF 36
                              BEGIN                                                      PRBEF 37
                                ERROR (16H(STACK UNDERFLOW.)) $                          PRBEF 38
                                RETURN $                                                 PRBEF 39
                              END                                                        PRBEF 40
                            IF FDDPS($ LASTIF   $) EQ MARK $                             PRBEF 41
                              BEGIN                                                      PRBEF 42
                                LASTIF = LASTIF + 1 $                                    PRBEF 43
                                GOTO STORE'END $                                         PRBEF 44
                              END                                                        PRBEF 45
                            LASTIF = LASTIF - 1 $                                        PRBEF 46
                            GOTO UNSTACK $                                               PRBEF 47
                         END                                                             PRBEF 48
```

APPENDIX V

This section contains the output listings from an example run of the modified JAVS. The example was designed to illustrate the use of our new assertion constructs and the use of JAVS as a preprocessor for those constructs. The program does nothing and in fact contains only one executable statement. (If there are no executable statements, JAVS ignores the module entirely.) The logical data structure that the assertions are being applied to is a two-dimensional array of records. More specifically, it is a sequential list of linked lists of records. Thus, to access each record, a CHAIN loop is nested within a LOOP loop. Within the inner loop, the VALUE and NOT VALUE assertions are each demonstrated. For illustrative purposes, all the possible optional clauses are used with each of the directives.

The first job activity is the JAVS basic source analysis during which the JAVS library for this particular program is built. In the next activity, JAVS is run again to generate the probed text from the original source and the directives. The third activity is a compool compilation that is necessary for compilation of the instrumented source code. The last activity demonstrates the compilation of the probed text.

```
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

  XXXX  XXXXXX XXXXX    X    XXXXX    X           XXXX   X
 X   X      y  X       XX      X     X           X   X    X
  XXXX     X   XXXXX    X      X     X     XXXX  X   X    X
 X   X    X        X    X      X     X           X   X    X
 X   X   X     X   X    X      X     X           X   X    X
  XXXX  X       XXXX   XXX     X      X           XXXX   X

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

0004  $      IDENT   BFCBNW06,NW06,558102780397,BLDPROBE
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

 X   X  X   X  XXXX     X          XXXXX  XXXXX  XXXX     X
 XX  X  X   X X    X   X           X      X      X    X  XX
 X X X  X   X X    X  XXXX         XXXXX  XXXXX   XXXX     X
 X  XX  X XX X X    X X    X           X      X  X    X    X
 X   XX XX  XX X    X X    X  XX  X    X X    X  X    X    X
 X    X X    X  XXXX   XXXX    X   XXXX   XXXX    XXXX    XXX

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

$$    8751T ENTERED SYST12 AT 19.756 FROM SYSTEM-0 TSS/S   0-20-03


0001  $      SNUMB    8751T
0002  $      COMMENT  BFCBNW06         TSS CARDIN
0003  $$     USERID   BFCBNW06$##########
0004  $      IDENT    BFCBNW06,NW06,558102780397,BLDPROBE
0005  $$     USERID   BFCBNW06$####
0006  $$     SELECT   BFCBNW08/STEP1-6
0007*A$      PROGRAM  RLHS
0008* $$     PRMFL    H*,R,R,BFCBNW08/MJAVS1-6
0009* $      LIMITS   99,82K,-5K,40000
0010* $      FILE     03,X3R,10R
0011* $      FILE     10,C1R,1L
0012* $      FILE     04,X4R,2L
0013  $$     PRMFL    02,R/W,R,BFCBNW06/LIBRARYJ
0014  $$     PRMFL    09,R,S,BFCBNW06/BCDBLK
0015  $$     SELECT   BFCBNW08/STEP2-6
0016*A$      PROGRAM  RLHS
0017* $$     PRMFL    H*,R,R,BFCBNW08/MJAVS2-6
0018* $      FILE     02,X2R,20R
0019* $      FILE     10,C1R,1L
0020* $      LIMITS   60,58K,-5K,20000
0021* $      FILE     03,X3R,10R
0022* $      FILE     04,X4R,2L
0023  $$     PRMFL    01,R,R,BFCBNW06/LIBRARYJ
```

```
0024  $       FILE     04,X4R,20R
0025  $$      PRMFL    07,W,S,BFCBNW06/BCDBLK
0026  $       LOWLOAD
0027  $       OPTION   FORTRAN
0028 A$       JOVIAL   NOPT,NDECK,NAMD/PBPOOL/,POOLOU/PC/
0029  $       FILE     PC,X1S,2L
0030  $$      SELECT   BFCBGRC1/COMPILEB
0031* $$      PRMFL    **,R,R,BFCBGRC1/BACKUP
0032* $       LIMITS   10,54K,,20000
0033* $       FILE     *6,C3D,2L
0034* $       FILE     *4,D4D,1L
0035* $       FILE     *7,E5D,1L
0036* $       FILE     *1,F6D,2L
0037* $       FILE     *5,G7D,1L
0038* $       FILE     *2,H8D,3L
0039* $       FILE     *3,I9D,3L
0040  $       LIMITS   1,49K
0041  $$      SELECT   BFCBGRC2/PBPOOL
0042 A$       JOVIAL   NOPT,NDECK,POOLIN/PC/
0043  $       FILE     PC,X1R,2L
0044  $$      SELECT   BFCBGRC1/COMPILEB
0045* $$      PRMFL    **,R,R,BFCBGRC1/BACKUP
0046* $       LIMITS   10,54K,,20000
0047* $       FILE     *6,C3D,2L
0048* $       FILE     *4,D4D,1L
0049* $       FILE     *7,E5D,1L
0050* $       FILE     *1,F6D,2L
0051* $       FILE     *5,G7D,1L
0052* $       FILE     *2,H8D,3L
0053* $       FILE     *3,I9D,3L
0054  $       LIMITS   10,49K
0055  $$      PRMFL    S*,R/W,S,BFCBNW06/BCDBLK
0056  $       ENDJOB
  TOTAL CARD COUNT THIS JOB = 000166


* ACTY-61  $CARD #0007* RLHS      05/08/78   SW=000000000000
  * NORMAL TERMINATION      AT 150471 I=4020 SW=000000000000

     START 19.946       LINES    203     PROC  0.0028       I/O   0.001    IU  5   MEMORY   82K
     STOP  19.951       LIMIT  40000     LIMIT 0.9900       LIMIT          CU  5   M*T     1689
     SWAP   0.000
     LAPSE  0.006 FC D    TYPE      BUST      IP/AT      EP/RT    IS/#C MS/#E     ADDRESS TN/PK#

                  I* R    D191 *      37          0          1        1     1     0-20-03
                  H* R    D191 P    1314          0          0      468   468R    0-20-01
                  03 R    D191 *      52          0          0      120   120R    0-20-04
                  10 R    D191 *      61          0          1       12    12     0-20-05
                  04 R    D191 *      49          0          1       24    24     0-20-02
                  02 R    D191 P    1563          0          0       50    50R    2-17-00
                  09 R    WHAT        53     19.945     19.951       27   3-01-00
                  P*      SYOUT

     RC-06   203 LINES AT STA.  -D

               CPU      SYSOUT       TAPE       DISK    PRINTER     READER      PUNCH    CONSOLE      FIXED      TOTAL
RATE        225.00        .002     .00031     .00005     .00006     .00065     .00002       0.00       0.00
CHARGE     0000.63     0000.41    0000.00    0000.15    0000.00    0000.00    0000.00    0000.00    0000.00    0001.19
```

```
* ACTY-02  $CARD #0016* RLHS       05/08/78    SW=000000000000
  * NORMAL TERMINATION        AT 104411 I=4020 SW=000000000000

     START 19.952        LINES    252      PROC  0.0039       I/O   0.002     IU  5   MEMORY    58K
     STOP  19.962        LIMIT  20000      LIMIT 0.6000      LIMIT            CU  5   M*T      2089
     SWAP   0.000
     LAPSE  0.010 FC D    TYPE       BUSY      IP/AT      FP/RT     IS/#C MS/#E    ADDRESS T#/PK#

                  I* R    D191 *       34          0          1         1     1    0-20-03
                  H* R    D191 P     1707          0          0       350   350R   0-20-01
                  10 R    D191 *       48          0          1        12    12    0-20-02
                  03 R    D191 *      456          0          0       120   120R   0-20-03
                  04 R    D191 *       59          0          1        24    24    0-20-04
                  01 R    WHAT        342     19.952     19,962         0   0-30-00
                  02 R    WHAT       1757     19,952     19,962        27   3-01-00
                  07 R    D191 P       87          0          4        12    12    0-20-01
                  P*      SYOUT

     PC-06    252 LINES AT STA.   -0

              CPU        SYSOUT        TAPE        DISK      PRINTER      READER       PUNCH     CONSOLE       FIXED        TOTAL
RATE        225.00        .002       .00031      .00005      .00006      .00065      .00002       0.00        0.00
CHARGE     0000.88     0000.50      0000,00     0000.12     0000.00     0000,00     0000.00     0000.00     0000.00      0001.50

* ACTY-03  $CARD #0028  JOVIAL   05/08/78    SW=000200000000
  * NORMAL TERMINATION       AT 002576 I=5000 SW=000200000000

     START 19.963        LINES    114      PROC  0.0004       I/O   0.001     IU  5   MEMORY    49K
     STOP  19.964        LIMIT  20000      LIMIT 0.0100      LIMIT            CU  5   M*T       337
     SWAP   0.000
     LAPSE  0.002 FC D    TYPE       BUSY      IP/AT      FP/RT     IS/#C MS/#E    ADDRESS T#/PK#

                  S* R    D191 *       45          0          5         5     5    0-20-03
                  D* R    D191 *       14          0          1         1     1    0-20-03
                  PC S    D191 *       61          0          0        24    24    0-20-02
                  ** R    D191 P     1312          0          0       960   960R   0-20-01
                  *6 R    D191 *       31          0          0        24    24    0-20-03
                  *4 R    D191 *       51          0          0        12    12    0-20-02
                  *7 D    WHAT          0     19.963     19,964        27   3-01-00
                  *1 R    D191 *        0          0          0        24    24    0-20-04
                  *5 R    D191 *        0          0          0        12    12    0-20-06
                  *2 R    D191 *        0          0          0        36    36    0-20-02
                  *3 R    D191 *        0          0          0        36    36    0-20-03
                  P*      SYOUT
                  K*      SYOUT
                  C*      SYOUT

     LIST     114 LINES AT STA.   -0

              CPU        SYSOUT        TAPE        DISK      PRINTER      READER       PUNCH     CONSOLE       FIXED        TOTAL
RATE        225.00        .002       .00031      .00005      .00006      .00065      .00002       0.00        0.00
CHARGE     0000.09     0000.23      0000,00     0000.08     0000.00     0000.00     0000.00     0000.00     0000.00      0000.40
```

```
* ACTY-04  SCARD #0042  JOVIAL   05/08/78   SW=000200000000
  * NORMAL TERMINATION      AT 002576 I=5000 SW=000200000000

     START 19.965       LINES     86       PROC  0.0005        I/O   0.001     IU  5   MEMORY    49K
     STOP  19.967       LIMIT  20000       LIMIT 0.1000       LIMIT            CU  5   M*T       385
     SWAP   0.000
     LAPSE  0.002 FC D    TYPE       BUSY     IP/AT      FP/RT     IS/#C MS/#E     ADDRESS T#/PK#

                  FC R   D191 *       52         0          0        24    24     0-20-02
                  D* R   D191 *       17         0          1         1     1     0-20-03
                  ** R   D191 P     1675         0          0       960   960R    0-20-01
                  *6 R   D191 *       54         0          0        24    24     0-20-03
                  *U R   D191 *       21         0          0        12    12     0-20-02
                  *7 D   WHAT         50    19.965     19.967         0   0-30-00
                  *1 R   D191 *       73         0          0        24    24     0-20-04
                  *5 R   D191 *       15         0          0        12    12     0-20-06
                  *2 R   D191 *       84         0          0        36    36     0-20-02
                  *3 R   D191 *        0         0          0        36    36     0-20-03
                  S* R   D191 P       85         0          5        12    12     0-20-01
                  P*     SYOUT
                  K*     SYOUT
                  C*     SYOUT

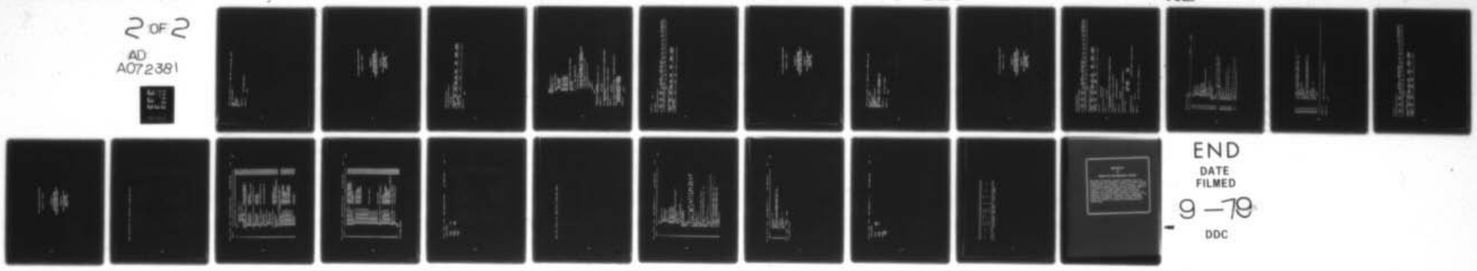
     LIST     86 LINES AT STA.  -0

                CPU      SYSOUT       TAPE       DISK     PRINTER      READER       PUNCH     CONSOLE      FIXED       TOTAL
RATE         225.00        .002     .00031     .00005      .00006      .00065      .00002        0.00       0.00
CHARGE      0000.11     0000.17    0000.00    0000.10     0000.00     0000.00     0000.00     0000.00    0000.00     0000.36
```

AD-A072 381 NORTHWESTERN UNIV EVANSTON IL DEPT OF ELECTRICAL ENG--ETC F/G 9/2
DYNAMIC MONITORING FOR LINEAR LIST DATA STRUCTURES.(U)
JUN 79 S S YAU, J L RAMEY F30602-76-C-0397

UNCLASSIFIED RADC -TR-79-128 NL

2 OF 2
AD
A072381



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9-79
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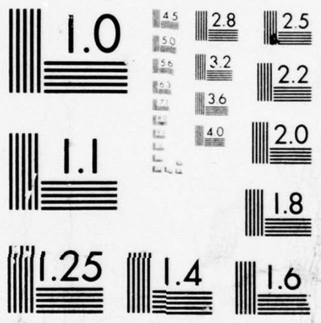

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
SNUMB = 8751T, ACTIVITY # = 01. , REPORT CODE = 06, RECORD COUNT = 000203

CREATE LIBRARY=LIBRARYJ.
START.
BASIC.
FOR LIBRARY.
STRUCTURAL.
END FOR.
END.

COMMAND IS...
                  CREATE LIBRARY=LIBRARYJ.

COMMAND IS...
                  START.
```

```
                 JOVIAL AUTOMATED VERIFICATION SYSTEM

                        VERSION 2.2   06-03-77



                             SPONSORED BY

                      AIR FORCE SYSTEMS COMMAND
                    ROME AIR DEVELOPMENT CENTER
             GRIFFISS AIR FORCE BASE, NEW YORK 13441
                  UNDER CONTRACT F30602-73-C-0348

                             DEVELOPED BY

                  GENERAL RESEARCH CORPORATION
                          P. O. BOX 3587
                          SANTA  BARBARA
                        CALIFORNIA   93105
```

```
STARTER INITIALIZATION...

KNOWN MODULE DESCRIPTOR BLOCKS...

     SYSTEM EMPTY

LIBRARY INFORMATION--RUN OF 0508
   LIBRARY       TYPE       DATE   TIMES   LAST   TOTAL      LLINKS     LIBRARY    LIBRARY
NO. NAME        ACCESS    CREATED ALTERED ALTERED WORDS       USED      MODULES   FRAGMENTS
-------------------------------------------------------------------------------------------
 1  **NOT OPENED**
 2 LIBRARYJ      NEW        0508      1    0508     20          1          0          3
-------------------------------------------------------------------------------------------

COMMAND IS...
                     BASIC.
```

```
                    START $
                    DEFINE INTG ''I 24 S'' $
                    DEFINE NN ''5'' $
                    DEFINE MAXRECS ''100'' $

                       TABLE MATRIX R MAXRECS $
                       BEGIN
                          ITEM LINK INTG $
                          ITEM XX INTG $
                          ITEM YY INTG $
                       END
                       ARRAY PTR NN INTG $
                       ARRAY LOCNT NN INTG $
                       ARRAY HICNT NN INTG $
                       ARRAY LOBND NN INTG $
                       ARRAY HIBND NN INTG $

                       ''DECLARATIONS FOR ASSERTION INDEX VARIABLES''
                       ITEM II INTG $
                       ITEM KK INTG $

                       II = 0 $  ''NEED AN EXECUTABLE STMT''

                       ''.LOOP (KK) (0...NN-1)''

                          ''.CHAIN (II) INIT (PTR($KK$)) NEXT (LINK($II$))
                          END (II EQ -1) EMPTY (PTR($KK$) EQ -1 ) COUNT (LOCNT($KK$)
                          ...HICNT($KK$)) BOUNDS (LOBND($KK$)...HIBND($KK$))''

                          ''.VALUE (XX($II$)) (-11...1, 3, 9...14)''

                          ''.VALUE (YY($II$)) NOT (1, 4...7)''

                          ''.ENDCHAIN''

                       ''.ENDLOOP''

                    TERM $
*NOMAIN* (*NOJAVS*) COMPLETED
     ********    NO ERRORS WERE FOUND BY JAVS-2  ******

COMMAND IS...
               FOR LIBRARY.

THE FOLLOWING MODULES HAVE BEEN QUEUED FOR PROCESSING BY SUBSEQUENT COMMANDS
     *NOMAIN*(*NOJAVS*)

MODULE SELECTED IS <*NOMAIN*> OF JAVSTEXT <*NOJAVS*>

COMMAND IS...
               STRUCTURAL.

JOVIAL AUTOMATED VERIFICATION SYSTEM   *** SECONDARY MODULE ANALYSIS ***

MODULE  *NOMAIN*  OF JAVSTEXT  *NOJAVS*
      MODULE DEPENDENCE TABLE CONSTRUCTED.
      STATEMENT DESCRIPTOR BLOCKS UPDATED.
      DD-PATH TABLE CONTAINS     1 ENTRIES.

COMMAND IS...
               END FOR.
```

```
COMMAND IS...
        END.

JAVS WRAPUP...

KNOWN MODULE DESCRIPTOR BLOCKS...

    MODULE      TEXT     PARENT         PROC PROBE       EXEC FIRST  WORD                                    DS   PARMS DIRECT COMP
NO.  NAME       NAME      NAME    TYPE SCOPE LINS STMTS STMTS  EXEC PAIRS  TOKS  SYMS  SLTS  DMTS  DDPS  BLKS  IN OUT CODE TOT DDP
------------------------------------------------------------------------------------------------------------------------------------
  1 *NOMAIN* *NOJAVS* *NOMAIN* PROG  EXT     0    25     1    17   260   203     0    14     0     1     2   0   0  NO    0   0
------------------------------------------------------------------------------------------------------------------------------------
                               TOTAL         0    25     1                                    1

LIBRARY INFORMATION--RUN OF 0508
   LIBRARY      TYPE     DATE   TIMES   LAST    TOTAL       LLINKS       LIBRARY    LIBRARY
NO. NAME       ACCESS   CREATED ALTERED ALTERED WORDS        USED        MODULES   FRAGMENTS
----------------------------------------------------------------------------------------------
 1  **NOT OPENED**
 2 LIBRARYJ     NEW      0508     1     0508    4520          16            1          9
----------------------------------------------------------------------------------------------
```

JOVIAL AUTOMATED VERIFICATION SYSTEM

VERSION 2.2 06-03-77

SPONSORED BY

AIR FORCE SYSTEMS COMMAND
ROME AIR DEVELOPMENT CENTER
GRIFFISS AIR FORCE BASE, NEW YORK 13441
UNDER CONTRACT F30602-73-C-0348

DEVELOPED BY

GENERAL RESEARCH CORPORATION
P. O. BOX 3587
SANTA BARBARA
CALIFORNIA 93105

```
 SNUMB = 8781T, ACTIVITY # = 02, , REPORT CODE = 06, RECORD COUNT = 000252

OLD LIBRARY = LIBRARYJ.
START.
JAVSTEXT='NOJAVS'.
FOR JAVSTEXT.
INSTRUMENT,MODE=DIRECTIVES.
INSTRUMENT.
END FOR.
PRINT, JAVSTEXT = 'NOJAVS', INSTRUMENTED = ALL.
PUNCH, JAVSTEXT = 'NOJAVS', INSTRUMENTED = ALL.
END.

COMMAND IS...
                  OLD LIBRARY = LIBRARYJ.

COMMAND IS...
                  START.
```

```
JOVIAL AUTOMATED VERIFICATION SYSTEM

VERSION 2.2   06-03-77


SPONSORED BY

AIR FORCE SYSTEMS COMMAND
ROME AIR DEVELOPMENT CENTER
GRIFFISS AIR FORCE BASE, NEW YORK 13441
UNDER CONTRACT F30602-73-C-0344

DEVELOPED BY

GENERAL RESEARCH CORPORATION
P. O. BOX 3587
SANTA BARBARA
CALIFORNIA  93105
```

```
STARTER INITIALIZATION...

KNOWN MODULE DESCRIPTOR BLOCKS...

     MODULE     TEXT      PARENT        PROC PROBE        EXEC FIRST  WORD                                          DS   PARMS DIRECT COMP
NO.   NAME      NAME       NAME    TYPE SCOPE LINS STMTS STMTS  EXEC PAIRS  TOKS  SYMS  SLTS  DMTS  DDPS  BLKS IN OUT CODE TOT DDP
------------------------------------------------------------------------------------------------------------------------------------
  1 *NOMAIN* *NOJAVS* *NOMAIN* PROG  EXT    0    25     1    17   260   203     0    14     0     1     2   0   0  NO    0   0
------------------------------------------------------------------------------------------------------------------------------------
                               TOTAL        0    25     1                                        1

LIBRARY INFORMATION--RUN OF 0508
   LIBRARY     TYPE      DATE   TIMES   LAST    TOTAL      LLINKS    LIBRARY    LIBRARY
NO. NAME      ACCESS   CREATED ALTERED ALTERED  WORDS       USED     MODULES   FRAGMENTS
-------------------------------------------------------------------------------------------
  1 LIBRARYJ   READ     0508     1      0508    4520         16         1          9
  2 SCRATCH    NEW      0508     1      0508      20          1         0          3
-------------------------------------------------------------------------------------------

COMMAND IS...
                  JAVSTEXT=*NOJAVS*.

JAVSTEXT <*NOJAVS*> IS NOW ACTIVE

COMMAND IS...
                  FOR JAVSTEXT.

THE FOLLOWING MODULES HAVE BEEN QUEUED FOR PROCESSING BY SUBSEQUENT COMMANDS
      *NOMAIN*(*NOJAVS*)

MODULE SELECTED IS <*NOMAIN*> OF JAVSTEXT <*NOJAVS*>

COMMAND IS...
                  INSTRUMENT,MODE=DIRECTIVES.

COMMAND IS...
                  INSTRUMENT.

JOVIAL AUTOMATED VERIFICATION SYSTEM *** INSTRUMENTATION ***

OPTIONS IN EFFECT . . .
                            DD-PATH PROBE =          PROBE
                            MODULE  PROBE =          PROBM
                            TEST    PROBE =          PROBI

INSTRUMENTING DIRECTIVES                       OF MODULE <*NOMAIN*> OF JAVSTEXT <*NOJAVS*>

COMMAND IS...
                  END FOR.

COMMAND IS...
                  PRINT, JAVSTEXT = *NOJAVS*, INSTRUMENTED = ALL.
```

```
JAVSTEXT <*NOJAVS*> LISTING

 NO.  LVL            STATEMENT                                                          DD-PATHS          CONTROL
--------------------------------------------------------------------------------------------------------------------

   1 ( 0)              START
   2 ( 0)              $
   3 ( 0)              TABLE MATRIX R 100 $
   4 ( 1)                BEGIN
   5 ( 1)                ITEM LINK I 24 S $
   6 ( 1)                ITEM XX I 24 S $
   7 ( 1)                ITEM YY I 24 S $
   8 ( 1)                END
   9 ( 0)              ARRAY PTR 5 I 24 S $
  10 ( 0)              ARRAY LOCNT 5 I 24 S $
  11 ( 0)              ARRAY HICNT 5 I 24 S $
  12 ( 0)              ARRAY LOBND 5 I 24 S $
  13 ( 0)              ARRAY HIBND 5 I 24 S $
  14 ( 0)              '' DECLARATIONS FOR ASSERTION INDEX VARIABLES ''
  15 ( 0)              ITEM II I 24 S $
  16 ( 0)              ITEM KK I 24 S $
  17 ( 0)              II = 0 $
  18 ( 0)              '' NEED AN EXECUTABLE STMT ''                                  (   1)
  19P( 0)           ''. LOOP    (   KK  )   (   0   ... 5   -   1   )   ''
  19P( 0)           ITEM JAVS'ASSERT H 72 $
  19P( 0)           MONITOR JAVS'ASSERT $
  19P( 0)           BEGIN
  19P( 0)           KK = 0 $
  19P( 0)           J00190.
  20P( 0)           ''. CHAIN   (   II  )  INIT    (   PTR ($  KK  $)  )   NEXT    (   LINK
                        ($  II  $)  )  END (   II  EQ  -   1   )   EMPTY   (   PTR ($  KK
                    $)  EQ  -   1   )   COUNT   (   LOCNT   ($  KK  $)  ... HICNT   ($  KK
                    $)  )   BOUNDS  (   LOBND   ($  KK  $)  ... HIBND   ($  KK  $)  )   ''
  20P( 0)           IF NOT (PTR ($ KK $) EQ - 1) $
  20P( 0)           BEGIN
  20P( 0)           ITEM ASSCNT I 24 S $
  20P( 0)           ASSCNT = 0 $
  20P( 0)           II = PTR ($ KK $) $
  20P( 0)           J00200.
  20P( 0)           IF NOT (LOBND ($ KK $) LQ II LQ HIBND ($ KK $)) $
  20P( 0)           BEGIN
  20P( 0)           JAVS'ASSERT = 35H(BOUNDS ASSERTION ERROR AT STMT   20) $
  20P( 0)           GOTO J00201 $
  20P( 0)           END
  20P( 0)           ASSCNT = ASSCNT + 1 $
  21P( 0)           ''. VALUE   (   XX  ($  II  $)  )   (   -   11  ... 1   ,   3   ,   9
                    ... 14  )   ''
  21P( 0)           IF NOT ((- 11 LQ XX ($ II $) LQ 1) OR (XX ($ II $) EQ 3) OR (9 LQ XX ($
                    II $) LQ 14)) $
  21P( 0)           JAVS'ASSERT = 34H(VALUE ASSERTION ERROR AT STMT   21) $
```

```
22P( 0)         ''. VALUE   (   YY  ($  II  $)  )   NOT (   1   ,   4   ... 7   )   ''
22P( 0)         IF ((YY ($ II $) EQ 1) OR (4 LQ YY ($ II $) LQ 7)) $
22P( 0)         JAVS'ASSERT = 34H(VALUE ASSERTION ERROR AT STMT   22) $
23P( 0)         ''. ENDCHAIN     ''
23P( 0)         II = LINK ($ II $) $
23P( 0)         IF NOT (II EQ - 1) $
23P( 0)         GOTO J00200 $
23P( 0)         J00201.
23P( 0)         IF NOT (LOCNT ($ KK $) LQ ASSCNT LQ HICNT ($ KK $)) $
23P( 0)         JAVS'ASSERT = 34H(COUNT ASSERTION ERROR AT STMT   23) $
23P( 0)         END
24P( 0)         ''. ENDLOOP ''
24P( 0)         ~~KK = KK + 1 $~~
24P( 0)         IF NOT (KK GR 5 - 1) $
24P( 0)         GOTO J00190 $
24P( 0)         END
25 ( 0)            TERM $
------------------------------------------------------------------------------------------------------
COMMAND IS...
                PUNCH. JAVSTEXT = *NOJAVS*. INSTRUMENTED = ALL.

COMMAND IS...
                END.
```

```
JAVS WRAPUP...

KNOWN MODULE DESCRIPTOR BLOCKS...

     MODULE     TEXT     PARENT           PROC PROBE         EXEC FIRST  WORD                                             DS   PARMS DIRECT COMP
NO.   NAME      NAME      NAME     TYPE SCOPE LINS STMTS STMTS  EXEC PAIRS  TOKS  SYMS  SLTS  DMTS  DDPS  BLKS  IN OUT CODE TOT DDP
-------------------------------------------------------------------------------------------------------------------------------------
  1 *NOMAIN* *NOJAVS* *NOMAIN* PROG  EXT    57    25      1    17   260   203     0    14     0     1     2   0   0  NO   0   0
-------------------------------------------------------------------------------------------------------------------------------------
                                   TOTAL    57    25      1                                          1

LIBRARY INFORMATION--RUN OF 0508
   LIBRARY       TYPE       DATE   TIMES    LAST    TOTAL        LLINKS      LIBRARY     LIBRARY
NO. NAME        ACCESS    CREATED ALTERED ALTERED   WORDS         USED       MODULES    FRAGMENTS
-------------------------------------------------------------------------------------------------
 1 LIBRARYJ      READ       0508     1      0508     4520          16           1            9
 2 SCRATCH       NEW        0508     1      0508     5520          19           1           11
-------------------------------------------------------------------------------------------------
```

```
                JOVIAL AUTOMATED VERIFICATION SYSTEM

                      VERSION 2.2   06-03-77


                            SPONSORED BY

                   AIR FORCE SYSTEMS COMMAND
                  ROME AIR DEVELOPMENT CENTER
           GRIFFISS AIR FORCE BASE, NEW YORK 13441
              UNDER CONTRACT F30602-73-C-0348

                            DEVELOPED BY

                 GENERAL RESEARCH CORPORATION
                        P. O. BOX 3587
                         SANTA  BARBARA
                      CALIFORNIA   93105
```

```
SNUMB = 0781T, ACTIVITY # = 03, REPORT CODE = 74, RECORD COUNT = 000118
```

```
8751T 03  05-08-78   19.963    COMPOOL COMPILATION OF PRPOOL          JOCIT VERSION 042275              PAGE     1

 ALTER NO        ****5****1****5****2****5****3****5****4****5****5****5****6****5****7****5****8            ANZC

    1            ''.JAVSTEXT PRCMPL PRESET = COMPOOL FOR PROBE ANALYSIS DURING EXECUTION 0319NB62
    2            ''                                                                      0319NB63
    3            START $                                                                 0319NB64
    4                    DEFINE INTG '' I 24 S '' $                                      DEFINS 2
    5                    DEFINE HLL '' H 4 '' $                                          DEFINS 3
    6                    DEFINE DINTG '' I 48 S '' $                                     DDEFINS2
    7                    DEFINE DHLL '' H 8 '' $                                         DDEFINS3
    8            DEFINE MAXDDP ''2000'' $         ''MAXIMUM DD-PATHS SUMMARIZED ''       0319NB67
    9            DEFINE MAXMOD ''100'' $          ''MAXIMUM MODULES SUMMARIZED ''        0319NB68
   10            PROC PROBM (MODNAM,JAVTXT,NDDPS) $ ''MODULE INVOCATION CALL ''          0319NB69
   11              BEGIN                                                                 0319NB10
   12              ITEM MODNAM DHLL $             ''MODULE NAME ''                       0319NB11
   13              ITEM JAVTXT DHLL $             ''JAVSTEXT NAME ''                     0319NB12
   14              ITEM NDDPS INTG $              ''NUMBER OF DD-PATHS IN MODULE ''      0319NB13
   15              END                                                                   0319NB14
   16            PROC PROBB(MODNAM,JAVTXT,DDP) $ ''DD-PATH EXECUTION CALL ''             0319NB15
   17              BEGIN                                                                 0319NB16
   18              ITEM MODNAM DHLL $             ''MODULE NAME ''                       0319NB17
   19              ITEM JAVTXT DHLL $             ''JAVSTEXT NAME ''                     0319NB18
   20              ITEM DDP INTG $                ''DD-PATH NUMBER ''                    0319NB19
   21              END                                                                   0319NB20
   22            PROC PROBI (TESNAM,TFLAG) $    ''TEST START/TERMINATION CALL ''         0319NB21
   23              BEGIN                                                                 0319NB22
   24                ITEM TESNAM H 8  $                                                  0319NB23
   25              ITEM TFLAG INTG $              ''TEST START/TERMINATION FLAG ''       0319NB24
   26              END                                                                   0319NB25
   27              PROC PROBD(LINE,FLAG) $                                               0319NB26
   28                BEGIN                                                               0319NB27
   29                ITEM LINE H 80 $                                                    0319NB28
   30                ITEM FLAG INTG $                                                    0319NB29
   31                END                                                                 0319NB30
   32            PROC DATIM(IDATE,ITIME) $      ''SYSTEM DATE CALL ''                    0319NB31
   33                                           ''SYSTEM TIME-OF-DAY CALL ''             0319NB32
   34            PROC PTIME (TIME)$             ''SYSTEM ELAPSED TIME CALL ''            0319NB33
   35            COMMON PROBEC $                ''COMMON BLOCK FOR PROBE PROCEDURES ''   0319NB34
   36              BEGIN                                                                 0319NB35
   37               FILE AUDIT B 1 R 8 V(OK) V(X1) V(X2) V(X3) V(EOF) 08 $
   38            ITEM CLOSED INTG P 0 $  ''CLOSE FLAG ON AUDIT FILE ''
   39              ITEM DATE DHLL $               ''DATE ''                              0319NB37
   40              ITEM NDDPP INTG P 0 $          '' NUMBER OF DDPATHS PROBED''          0319NB38
   41              ITEM NMODI INTG P 0 $          ''NUMBER OF MODULES INVOKED''          0319NB39
   42              ITEM NMODS INTG P 0 $          ''NUMBER OF MODULES''                  0319NB40
   43              ITEM NTESTS INTG P 0 $         ''NUMBER OF TESTS''                    0319NB41
   44              ITEM OPENED INTG P 0 $         ''OPEN FLAG ON FILE AUDIT''            0319NB42
   45              ITEM PROBEN INTG P 0 $         ''NUMBER OF PROBES EXECUTED''          0319NB43
   46              ITEM TESTN INTG P 0 $          ''NUMBER OF TESTS EXECUTED''           0319NB44
   47              ITEM TIMEO F P 0.0 $                                                  0319NB45
   48              ITEM DELTAT F P 0.0 $                                                 0319NB46
   49              ITEM TOD DHLL $                ''TIME-OF-DAY ''                       0319NB47
   50              ITEM TIME F $                  ''ELAPSED TIME ''                      0319NB48
```

```
87517 03  05-08-78   19.963    COMPOOL COMPILATION OF PRPOOL         JOCIT VERSION 042275            PAGE     2

  ALTER NO        ****5****1****5****2****5****3****5****4****5****5****5****6****5****7****5****8            ARZC

    51              ITEM MXMOD INTG F MAXMOD $  ''MAXIMUM MODULES SUMMARIZED ''          0319NB49
    52              ITEM NMOD INTG F 0 $        ''NUMBER OF MODULES SUMMARIZED ''        0319NB50
    53              ITEM MXDDP INTG F MAXDDP $  ''MAXIMUM DD-PATHS SUMMARIZED ''         0319NB51
    54              ITEM NDDP INTG F 0 $        ''NUMBER OF DD-PATHS SUMMARIZED ''       0319NB52
    55              ITEM PROBEF INTG F 2 $      ''PROBE CAPTURE FLAG ''                  0319NB53
    56              TABLE PRBUFR R 1 S 8 $      ''TEST BUFFER ''                         0319NB54
    57                BEGIN                                                              0319NB55
    58                 ITEM RECORD HLL 0 0 $    ''TEST RECORD TYPE ''                    0319NB56
    59                 ITEM NAME1 DHLL 1 0 $    ''FIRST NAME IN RECORD ''                0319NB57
    60                 ITEM NAME2 DHLL 3 0 $    ''SECOND NAME IN RECORD ''               0319NB58
    61                 ITEM NAME3 DHLL 5 0 $    ''THIRD NAME IN RECORD ''                0319NB59
    62                 ITEM INTG1 INTG 1 0 $    ''FIRST INTEGER IN RECORD ''             0319NB60
    63                 ITEM INTG2 INTG 2 0 $                                             0319NB61
    64                 ITEM INTG3 INTG 3 0 $                                             0319NB62
    65                 ITEM INTG4 INTG 4 0 $                                             0319NB63
    66                 ITEM INTG5 INTG 5 0 $                                             0319NB64
    67                 ITEM INTG6 INTG 6 0 $                                             0319NB65
    68                 ITEM INTG7 INTG 7 0 $                                             0319NB66
    69                 ITEM REAL1 F 1 0 $       ''FIRST REAL IN RECORD ''                0319NB67
    70                 ITEM REAL2 F 2 0 $                                                0319NB68
    71                 ITEM REAL3 F 3 0 $                                                0319NB69
    72                 ITEM REAL4 F 4 0 $                                                0319NB70
    73                 ITEM REAL5 F 5 0 $                                                0319NB71
    74                 ITEM REAL6 F 6 0 $                                                0319NB72
    75                 ITEM REAL7 F 7 0 $                                                0319NB73
    76                 ITEM CARD H 40 1 0 $     ''HALF CARD IMAGE''                      0319NB74
    77                END                                                                0319NB75
    78              TABLE MODSUM R MAXMOD S 9 $ ''MODULE SUMMARY WORKSPACE ''            0319NB76
    79                BEGIN                                                              0319NB77
    80                 ITEM MOD DHLL 0 0 $      ''MODULE NAME ''                         0319NB78
    81                 ITEM TXT DHLL 2 0 $      ''JAVSTEXT NAME ''                       0319NB79
    82                 ITEM MBASE INTG 4 0 $    ''BASE IN DD-PATH WORKSPACE ''           0319NB80
    83                 ITEM MINV INTG 5 0 $     ''NUMBER OF INVOCATIONS ''               0319NB81
    84                 ITEM MRET INTG 6 0 $     ''NUMBER OF RETURNS ''                   0319NB82
    85                 ITEM MDDP INTG 7 0 $     ''NUMBER OF DD-PATHS ''                  0319NB83
    86                 ITEM MTIM F 8 0 $        ''ELAPSED TIME IN MODULE AND UNDERLINGS'' 0319NB84
    87                END                                                                0319NB85
    88              TABLE DDPSUM R MAXDDP S 1 $ ''DD-PATH SUMMARY WORKSPACE ''           0319NB86
    89                BEGIN                                                              0319NB87
    90                 ITEM DEX INTG 0 0 $      ''DD-PATH EXECUTION COUNT ''             0319NB88
    91                END                                                                0319NB89
    92               END                                                                 0319NB90
    93             TERM $                                                                0319NB91
** NO DIAGNOSTIC MESSAGES**
```

```
8751T 03  05-08-78    19.963    COMPOOL COMPILATION OF PRPOOL           JOCIT VERSION 042275              PAGE       3

   PROGRAM SUMMARY

   SYMDEFS            ADDR
      NONE

   COMMONS            SIZE
      PROBEC         005564

   SYMREFS
      NONE
```

```
SNUMB = 07B1T, ACTIVITY # = 04; . REPORT CODE = 74, RECORD COUNT = 000086
```

```
87517 04  05-08-78   19.966     JOVIAL COMPILATION OF ......          JOCIT VERSION 042275              PAGE      1
   ALTER NO       ****5****1****5****2****5****3****5****4****5****5****5****6****5****7****5****8               ANE1
      1                 START
      2                 $
      3                 TABLE MATRIX R 100 $
      4                   BEGIN
      5                   ITEM LINK I 24 S $
      6                   ITEM XX I 24 S $
      7                   ITEM YY I 24 S $
      8                   END
      9                 ARRAY PTR 5 I 24 S $
     10                 ARRAY LOCNT 5 I 24 S $
     11                 ARRAY HICNT 5 I 24 S $
     12                 ARRAY LOBND 5 I 24 S $
     13                 ARRAY HIBND 5 I 24 S $
     14                 '' DECLARATIONS FOR ASSERTION INDEX VARIABLES ''
     15                 ITEM II I 24 S $
     16                 ITEM KK I 24 S $
     17                 II = 0 $
     18                 '' NEED AN EXECUTABLE STMT ''
     19             ''. LOOP    (   KK  )    (   0   ... 5   -   1   )   ''
     20             ITEM JAVS'ASSERT H 72 $
     21             MONITOR JAVS'ASSERT $
     22             BEGIN
     23             KK = 0 $
     24             J00190.
     25             ''. CHAIN    (    II   )   EXIT     (    PTR ($  KK  $)  )    NEXT     (    LINK
     26                 ($  II  $)  )   END (    II   EQ  -     1   )    EMPTY    (    PTR ($  KK
     27             $)  EQ   -    1   )   COUNT   (    LOCNT   ($  KK  $)  ... HICNT   ($  KK
     28             $)  )   BOUNDS  (    LOBND   ($  KK  $)  ... HIBND   ($  KK  $)  )   ''
     29             IF NOT (PTR ($ KK $) EQ - 1) $
     30             BEGIN
     31             ITEM ASSCNT I 24 S $
     32             ASSCNT = 0 $
     33             II = PTR ($ KK $) $
     34             J00200.
     35             IF NOT (LOBND ($ KK $) LQ II LQ HIBND ($ KK $)) $
     36             BEGIN
     37             JAVS'ASSERT = 35H(BOUNDS ASSERTION ERROR AT STMT   20) $
     38             GOTO J00201 $
     39             END
     40             ASSCNT = ASSCNT + 1 $
     41             ''. VALUE   (   XX  ($  II  $)  )   (   -   11  ... 1   ,   3   ,   9
     42             ... 14  )   ''
     43             IF NOT ((- 11 LQ XX ($ II $) LQ 1) OR (XX ($ II $) EQ 3) OR (9 LQ XX ($
     44             II $) LQ 14)) $
     45             JAVS'ASSERT = 34H(VALUE ASSERTION ERROR AT STMT   21) $
     46             ''. VALUE   (   YY  ($  II  $)  )   NOT (   1   ,   4   ... 7   )   ''
     47             IF ((YY ($ II $) EQ 1) OR (4 LQ YY ($ II $) LQ 7)) $
     48             JAVS'ASSERT = 34H(VALUE ASSERTION ERROR AT STMT   22) $
     49             ''. ENDCHAIN    ''
     50             II = LINK ($ II $) $
```

```
0751T 04  05-08-78   19.966     JOVIAL COMPILATION OF ......          JOCIT VERSION 042275           PAGE     2

    ALTER NO        ****5****1****5****2****5****3****5****4****5****5****5****6****5****7****5****8         ANZ1

    51              IF NOT (II EQ - 1) $
    52              GOTO J00200 $
    53              J00201.
    54              IF NOT (LOCNT ($ KK $) LQ ABSCNT LQ HICNT ($ KK $)) $
    55              JAVS'ASSERT = 34H(COUNT ASSERTION ERROR AT STMT   23) $
    56              END
    57              ''. ENDLOOP ''
    58              KK = KK + 1 $
    59              IF NOT (KK GR 5 - 1) $
    60              GOTO J00190 $
    61              END
    62                  TERM $
   COMPOOL     FRPOOL        VERSION     050078

   ** NO DIAGNOSTIC MESSAGES**
```

```
87517 04  05-08-78   19.966     JOVIAL COMPILATION OF ......          JOCIT VERSION 042275            PAGE     3

   PROGRAM SUMMARY

   SYMDEFS         ADDR
      ......       000560

   COMMONS         SIZE
      NONE

   SYMREFS
      JOVMD.
      JOVMOV
      .JEXIT
```

```
***************************************************************
***************************************************************

   -    -    8751T    -    -

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***************************************************************
-- 3 0 --        DATE  05-09-78    TIME  12.944       PR 0 12   SYST12
```